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Environmental Threats and National Security:

An International Challenge to Science and Technology

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Environmental Threats and National Security

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Preface

As the world edges away from potential catastrophic conflict to more localized violence, the hope grows stronger that the root causes of regional and global problems can be systematically understood, and that cooperative efforts among nations and nongovernment parties can minimize consequent harm and conflict. That is the hope pursued in this volume.

Science will contribute critical understanding and new technology to this venture. It is clear, however, that the science needed for global security and its global implementation will stretch current technical disciplines and traditional institutions' limitations. With this in mind, a workshop on *Environmental Threats and National Security: A Challenge to Science and Technology* brought a spectrum of experts to Monterey, California, in December, 1996, to discuss the context and intersection of environmental and national security issues.

The meeting was hosted by the Lawrence Livermore National Laboratory: Center for Global Security Research; sponsored by the Departments of Energy, Defense, and State; and co-hosted by the University of California, Massachusetts Institute of Technology: Program for Environmental Engineering Education and Research, Stanford University: Institute for International Studies, Columbia University, and the Woodrow Wilson Center: Environmental Change and Security Project.

This volume contains the papers that were presented and discussed, grouped in four sections: policy development, global dimensions, regional dimensions, and specific threats. The overview offers a general introduction to the issues considered and observations summarizing the ideas presented. The last section includes relevant speeches and government documents. Finally, an index is included to help the reader locate the wide variety of topics that are important to this subject.

A number of people contributed to the success of the workshop. We would like to thank in particular P. J. Simmons of the Woodrow Wilson Center and Donald Kennedy of Stanford University for their advice and their knowledge of the broad community interested in these topics. We are also highly appreciative of Merry O'Brien for administrative help with both the workshop and this volume; Karen Blades, Chrystal Aceves, Scott Rock, Edie Alton, and Carole Thompson for assistance in the execution of the workshop; Dale Sprouse and Denise Kellom for preparation of this document for publication; and George Kitrinos for the cover design.

The interesting views expressed are those of the authors.

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List of Figures and Tables

Table of Contents

Part one: Overview

Introduction

Thomas J. Gilmartin
Braden R. Allenby
Ronald F. Lehman II

As we learn more about the oceans, atmosphere, biosphere, chemical cycles, and other global systems, we also learn more about humanity's growing influence over them. We begin to get a clearer idea of our possible futures, a mixture of opportunity and hazards, marked by the inexorable, if heretofore unintentional, increase in human domination — and therefore responsibility — over global processes and the life with which we coexist. At the same time, we are creatures of our history and the realities of human interactions and institutions. While a certain optimism derives from the end of the Cold War and the concomitant increase in human economic and political freedom, history warns us to be cautious about our ability to live peacefully and prosperously.

For centuries, the nation-state has been the predominant organizational structure defining global human activity. While nation-transcending organizations and relationships are increasingly influential, the supremacy of nation-states remains the case (Brown Weiss). Virtually all peoples profoundly value the integrity of their nation, their national security. In turn, this security is heavily dependent on international political stability and global economic access, especially for developed countries. Such security derives from civil international relations and openness, but experience has consistently demonstrated that it also must rely on military strength as well, that society at any level does not remain orderly and peaceful without a disciplinary force. Currently, this principle in practice means that much responsibility for world order, directly or indirectly, devolves to the United States.

At the same time the absolute scale and global integration of human activities, and the realization of the importance of environmental factors in achieving and sustaining a desirable quality of life, have added complexity to this picture. Such developments require of us more subtle and more complex approaches to the maintenance of our own security (Allenby: Dimensions). To claim that all issues which impact our well-being are at heart issues of national security is, of course, not true and not useful. To claim that national security responsibilities in the more complex post-Cold War era are satisfied by military capability alone is also inadequate to the effective pursuit of our future national interest.

The essays in this collection deal with some of the most important environmental issues which might affect national security, and with some of the contextual mechanisms — national policy and international law and agreements — which are being used to create a structure for their management. These essays do not knit into a coherent or comprehensive study — the field of study is not yet at that point — but do highlight some of the most important and complex problems and current responses to them. The articles also focus on issues and concerns from the perspective of the United States; this reflects both the composition of the workshop and the leading role of U.S. policymakers in developing this area (Dabelko and Simmons; Haspel; David). In the following few pages, we will introduce the reader to these topics.

Environmental issues

Environmental security is a term that is currently being used to encompass the intersection of national security and environmental issues. Clearly, on the one hand, the complex forcing functions that drive international relations and even international and intranational conflict have environmental elements. While the ability of environmental stress to increase the probability of conflict is generally considered to be the essence of "environmental security," it is the rare situation where "environmental" factors are the primary source of conflict (disputes over petroleum reserves are notable exceptions). Still, understanding high tension environmental factors concentrated in one locale might allow harmful confrontations to be anticipated and defused, and might enable the harm generated in ongoing violent situations to be minimized. This set of environmental issues is predominantly regional (Kennedy).

On the other hand, there are environmental situations that threaten all nations. In many cases, these perturbations, such as global climate changes and stratospheric ozone depletion, can cause great harm indiscriminately or even very locally, but do not threaten to cause conflict. This set of environmental issues is global and is generally identifiable with potential long-term economic and ecological instabilities.

In addition, there is currently an assignment of the term "environmental security" to environmentally responsible military operations, and the extension of these activities to alliance making through the sharing of good environmental practices with other nations' military establishments. This is a desirable and important confidence building activity, but it tends to be quite situation dependent. Consequently, this volume will concentrate on the general and specific aspects of r*egional* and *global* environmental issues, and their impact on the U.S. national security.

U.S. national security

Focusing first on the United States, it is useful to distinguish conceptual views of national security before bringing in the complexities of real situations. On the one hand, U.S. national security is identified with military superiority, the ability to win a conflict without any doubt, thereby both having the military resources when fighting is necessary and the dominance that deters opponents in the first place. This interpretation of national security responsibility, in addition to fighting war, includes international police actions, arms control, nonproliferation of weapons of mass destruction, and suppression of terrorism. Nuclear materials present other unique environmental and security issues (Schafer, et. al.).

At the other extreme, the broadest interpretation of national security includes all factors affecting the well-being of the citizens and economy of the United States, now and in the future. Such an interpretation includes, for examples, economic security and sustainable development issues.

In fact, most conflict situations in which the United States is currently engaged around the world involve both traditional issues of ethnic hostility, territory and resource control, and a complex array of contextual issues. And, the array of responses to these situations includes diplomacy, treaty negotiation, and nongovernmental actions, as well as military force. In real situations U.S. leaders are called upon to assess and balance a broad range of values in defining our national security, and to use an array of methods to respond.

International context

With the end of the Cold War, many regional instabilities have been unleashed, driven primarily by ethnic and cultural rivalries and underdeveloped social structures, and also by competition for limited resources and the collapse of national economic structures. While these situations are profoundly sad and often highly lethal, they do not threaten the United States directly unless they are of significant concern to powerful neighbors. Thus, local conflicts in Africa, South America, even Central Europe and Central America are often of less concern than those in the Middle East and around China and Japan. In the longer term, U.S. concerns are likely to center on the stability of those areas of the world where very rapid economic development will create an unpredictable mix of enormous economic power coupled with international competition and antagonism.

As Weiss points out, the nature of international interaction and law is changing profoundly from centuries past when the internal workings of interacting states were of little concern and nongovernment organizations (NGOs) had no standing or influence. Today, news and information of all types are accessible to and from all parts of the globe across all borders, and NGOs influence the day-to-day workings of business, government, and society, creating a new global fabric that is supranational. Optimistically, these mechanisms may uncover and diffuse potentially harmful circumstances before they reach conflict. Unfortunately, especially in periods of governmental transition, local unrest and conflict can be exacerbated by nongovernmental forces.

Global environmental issues

The human population is increasing, and human use of resources is increasing per capita. Without major changes in culture and technology, the impact of humans on the Earth will continue its nonlinear increase.

Global environmental parameters are changing (Corell) and to some extent these changes are anthropogenic. Glaciers are retreating; the sea level is rising; precipitation patterns are shifting; plant and animal habitats are diminishing; previously localized diseases are spreading (Murphy); and the consensus is that the global temperature is increasing and that weather patterns are changing. These changes are occurring gradually, but nonlinear and discontinuous consequences are both possible and evidenced in paleologic data. Indeed, the accelerating effect of humanity on the global environment guarantees some dramatic changes, even if they are unpredictable and unforeseen. Developing the scientific and sociological infrastructures to understand and manage these perturbations will be extremely important and difficult.

Understanding global atmospheric mechanisms is at least conceptually eased by the fact that they are integrative — that is, that they combine many separate and remote human actions into single forcing functions. The response of the system is thus largely independent of where, for example, the greenhouse gases or CFCs are released. Models for atmospheric chemistry and physics and interactions with the land and oceans are crossing the threshold of data integration, accuracy, and resolution that will provide credible global and eventually regional predictions (Eisenberger). And comprehensive, timely data are becoming available (Harriss; David). Our ability to predict the consequences of human actions will reinforce our responsibility for those consequences and the necessity to discipline ourselves on a scale that appears impossible at this time. We seem to be making progress in limiting our damage to the ozone layer, but is it possible to control the release of CO_2 into the atmosphere (Schipper)? And in the future might intimidation be used to enforce constraints on CO_2 production, thus making even global warming a risk factor for human conflict?

As our impact on the biosphere increases, we invade the habitats of other life forms with at least two adverse effects. We decrease Earth's biodiversity, thus increasing biovulnerability and losing the unpriced, but valuable services of ecosystems, such as wetlands' high ecological productivity and flood control. And we increase the release and diffusion of pathogens, bacteria, and viruses (Murphy). The diffusion of pathogens into new, and vulnerable, human and other biological communities would also be increased by global warming.

Regional environmental issues

Access to oil, gas, coal, water, and other resources is essential for industry and agriculture. Huge resource concentrations, such as those of the Middle East, and disputed ownership, such as the oil and gas in the South China Sea shelf, will increase the potential for conflict as these resources increase in value, as occurred recently in the Persian Gulf War. As the Pacific Rim tigers grow out of the third world, additional stresses will occur (Hayes, et. al.). Direct impacts of energy production, such as the exploitation of coal and hydroelectric energy resources, have in contrast generally caused very local, intranational problems, displacing inhabitants and marring landscapes for the benefit of distant customers.

The development of river basin systems is another source of regional conflict (Gleick). In the case of Turkey's development of the Euphrates River for hydroelectricity and irrigation, downstream countries will get less of this river's water and energy and considerable tension is likely. Huge hydroelectric projects in both China (Three Rivers Gorge) and Canada (Quebec) have high environmental and human impact, and their scale suggests that the full consequences are not foreseeable. Water is a key element of the Middle East peace agreements between Israel and its neighbors.

The need for agricultural resources is both a regional and global problem (Kane). In general, industrial, agricultural, urban, and natural-habitat systems compete for water and fertile land within every regional ecology. And where these resources overlap the boundaries of evolving societies, particularly in Africa, international relations are particularly dynamic.

Industrialization of production, including agriculture, leads to pollution, acidification, eutrophication, and occasionally to desertification, effects which are not confined to the offending industrial region. Tension between the United States and Canada, between Japan and China, and within Europe over acid rain, for example, illustrate one common, difficult to manage perturbation. Even when such effects are confined to the source nation, they can cause transitional quality-of-life stress, as in China (Smil), or severe debilitation, as in Russia (Feshbach), as well as significant environmental equity problems.

Flooding, droughts, famine, hurricanes and typhoons, tornadoes, and earthquakes are all regional risk factors. When occurrences of these disasters are repeated or prolonged, or when very sharp economic gradients occur because of resources inequities or concentrations, very large-scale migrations can occur, as is currently happening in Africa and China, and worldwide between wealth-disparate areas.

Coupling of the global and the regional

Global conditions couple to local in a variety of ways, for example, through major ocean currents and current cycles like El Niño; through wind, storm, and precipitation patterns; through exposure to solar radiation because of variations in the atmospheric composition and cloud cover; through the timing, duration, and intensity of local seasonal cycles; and through changes in the general conditions for the breeding and transfer of infection.

El Niño, for example, which clearly depends for its drive on global thermodynamics, is the cause of the precipitation patterns in South America, probably also in the west of North America, and is thought to be coupled to the generation of typhoons in the west Pacific. Global temperature changes will affect El Niño and the strength and temperature of other ocean currents and might even disrupt metastabilities causing major changes in ocean current patterns and local weather conditions (Corell).

The total precipitation in the northeastern United States is increasing steadily. This trend is statistically significant and the weather changes are probably permanent.

Flooding is occurring this year at the 500-year-flood level in the Ohio River and Red River basins, after several years of extraordinary flooding in California and in the Mississippi and Missouri River basins. During early 1997, more tornadoes occurred in Arkansas in one day than are normally experienced in a year. These events may be statistical anomalies, but are clearly in excess of historical patterns. The flood effects are exacerbated by wetland destruction and flood plain development, which, while they are not changed climate conditions, are quasi-permanent changes in the regional vulnerability to existing conditions.

While the ozone hole in the south latitudes is concentrated over the South Pole, periodic reduced ozone concentrations occur in the northern hemisphere over Europe, Russia, and the United States, concentrating the potential for increased skin cancer in these locations. Thus, the ozone-depletion by CFCs generated worldwide will preferentially impact these regions.

Finally, small increases in temperature are expected to increase the germination of infectious diseases making them more available to vectors which themselves may be increased by warming conditions. When this is coupled with the impingement of expanding populations into previously isolated and remote areas which all have their own fungi, bacteria, and viruses, and with the proliferation of megacities where infections could propagate quickly, the threat of disease will be increased by changing global conditions, but will concentrate in regions of dense population.

Through such mechanisms, global changes which might seem remote can focus their impact locally and lethally. These problems are especially difficult to address, however, because the forcing activities (e.g., CFC and greenhouse gas emissions) are not concentrated in the affected regions and the concomitant afflictions may not be felt until future generations. The motivation to discipline human activities is lacking because the offenders are not located in the time and place of the offended.

Environmental threats to U.S. national interests

All of the threats mentioned here and discussed in more detail later in this volume, be they regional or global, immediate or long term, will have the potential to influence U.S. national security and well-being. It is clearly in the best interest of the United States that the entire Earth be healthy, economically active, and managed rationally and responsibly. This is not only in the economic and ecological self interest of the United States, but coincident with our national values.

Thus, the scope of environmental issues relevant to the U.S. national interests contains at least two subsets: those that directly, immediately, and substantially impact U.S. security interests, and a much broader set that is more subtle and more diffuse, requiring attention, but not immediately affecting security (Allenby: Definition). Whereas the danger of immediate threats might be conflict, thus urging responses based on short-term conflict avoidance, the response to the broader set of issues will require cooperation based on credible science and a persuaded society. In many ways the less urgent environmental problems could prove to be the most difficult to deal with and the most threatening in the long run (Schipper).

Governmental responses to environmental threats

Environmental threats require large-scale cooperative responses, brought about either by a broad societal commitment or by national and international enforcement. Of course, the best situation occurs when people collectively and accurately perceive the environmental implications of their actions, and act in the common (environmental) interest. Unfortunately, this happy situation is rare because most often the benefits of such actions do not fall to those who would bear the costs.

The role of NGOs in these diffuse situations is of increasing importance and in many cases has superseded the formal roles of governments, particularly when the environment is at issue (Weiss). But, the roles of governments in establishing policies, enacting and enforcing intra- and international laws, and executing programs remain the primary mechanisms for modifying and controlling human actions. As the holistic nature of global human interactions emerges as the key to sustainable human institutions, security of the environment is an increasingly important element informing and driving government actions (Dabelko and Simmons). "Meeting the Challenge of Global Threats" comprises a major portion of the U.S. National Science and Technology Council's recently published *National Security Science and Technology Strategic Plan.* Relevant portions of this and other key documents are provided in the last section of this book.

The Department of Defense has set *preventive defense* as doctrine for the formation of its strategies, tactics, and operations (Perry). Defined as *winning without fighting,* this doctrine requires in part a thorough knowledge of the environmental factors which might cause conflict and methods for dealing with these threats. In addition, the Defense Department has established an Assistant Secretary for Environmental Security (Goodman), whose role is both to ensure that operations are environmentally appropriate and that environmental security is a basis for relations and alliances between the U.S. military and the military institutions of allies and friends.

When he was the Secretary of State, Warren Christopher stated in several speeches that environmental factors should be formative in U.S. foreign policy and foreign aid programs, and he established a responsibility for environmental issues within his department. Quoting from his speech (Christopher) at Stanford University on April 9, 1996,

> . . . our Administration has recognized from the beginning that our ability to advance our global interests is inextricably linked to how we manage the Earth's natural resources. That is why we are determined to put environmental issues where they belong: in the mainstream of American foreign policy.
>
> . . . The environment has a profound impact on our national interests in two ways: First, environmental forces transcend borders and oceans to threaten directly the health, prosperity, and jobs of American citizens. Second, addressing natural resource issues is frequently critical to achieving political and economic stability, and to pursuing our strategic goals around the world.
>
> In carrying out America's foreign policy, we will of course use our diplomacy backed by strong military forces to meet traditional and continuing threats to our security, as well as to meet new threats such as terrorism, weapons proliferation, drug trafficking, and international crime. But we must also contend with the vast new danger posed to our national interests by damage to the environment and resulting global and regional instability . . .. A foreign policy that failed to address such [environmental] problems would be ignoring the needs of the American people.

Finally, the U.S. Department of Energy (Haspel) will play a very important role in establishing relevant U.S. environmental policy and facing critical environmental threats, especially in the area of energy, increasingly the most valuable global resource and one of the greatest potential sources of conflict. In addition, the Department of Energy has obvious capabilities to both develop scientific understanding of, and technology responses to, the most pressing environmental issues.

Science and technology responses to environmental threats

The science of natural systems and of their interactions with human systems is a very high priority, if we are to understand the consequences of our choices and actions before the choices are made, and balance our needs with those of the rest of the biosphere in sustaining our quality of life. This understanding will be embodied in models of these systems and in data gathered worldwide and integrated into the models (Corell; Eisenberger; Harriss). Eventually we will have to comprehend the linkages from global conditions through ecological systems down to the explicit responses of genetic structures. In the nearer term, the accurate prediction of regional effects from global data will be of great benefit in regional distress management, emergency preparedness, optimized land use and food production, energy and emissions management, and development of cooperative conflict avoidance programs (Allenby: Definition). Anticipation of both global and local environmental impacts is critical. We cannot afford to wait until global changes have occurred and possibly unleashed irreversible processes. Such information will also be essential in the just and rational formulation of international law and treaties governing environmental actions (Lehman).

Models of regional systems are being developed currently. For example, watersheds and their coupling to freshwater surface systems and aquifers is already being modeled accurately. Such knowledge could help to avoid stress and conflict in the Middle East, in South Africa, and within India, China, and the western United States. Local atmospheric circulation models for emission management and emergency response to accidental release of hazardous gases are also now available. Both local water and air system models would be key in analyzing potential conflict situations before committing personnel and assets to a selected strategy. Eventually, the predictive and mitigatory power of these local and "mesoscale" models will be substantially enhanced by linking them to global-scale models of ocean, atmospheric, and biological systems.

Technological innovation may be the solution to some vexing environmental security problems. If clean, inexpensive point and transportable energy were available without geographic constraints; if abundant fresh water were available wherever needed; if nourishing food could be grown under what now appear to be inhospitable conditions; if more effective antifungal, antibiotic, and antiviral remedies existed; if better sensors existed and data bases were accessible for hazardous agents; if cost-efficient remediation and restoration methods for organic, metallic, and radioactive contamination were available; if global observation systems and data networks were operational, many environmental situations which are currently threatening, potentially conflictful, or already harmful might be avoided or repaired. In some cases, the economic value of technological solutions remains to be demonstrated; credible integrated assessment models and data could demonstrate this value and enable prioritization of the solutions.

Obviously, cooperation among nations and impacted regional groups, and among industry, academia, and NGO networks (Kauffman), will be important in defeating environmental threats without creating new problems. In particular, predicative models and accurate global agricultural data will afford economic advantages which will be prized and coveted. As is often the case, the first use of new technical knowledge can be as a means of achieving local advantage, which may initially hinder worldwide implementation and benefit realization. The more widely available any of the technology innovations just mentioned, the greater will be the relief from environmental stress and potential conflict, and thus, in all likelihood, the greater will be the long-term security benefit to the United States.

Summary observations

Paul L. Chrzanowski

The introductory and subsequent articles in this book, including the foundational material contained in Section 6, present significantly more information than was discussed at the workshop, "Environmental Threats and National Security: An International Challenge to Science and Technology." However, the workshop discussions served to integrate and emphasize some of the most important points raised in these papers. The following observations draw from both the workshop and the papers.

Six principal points are raised:

- <u>The Importance of Environmental Issues</u>. At the end of the 20th century, most projections indicate that the world will double in population by the year 2050. Much of the increase will be in developing countries, which are simultaneously striving to attain a higher standard of living for their people. The stress on the limited common resources of the planet—air, water systems, fossil fuels, and land for agricultural use—will be enormous and unevenly distributed. Localized impacts on biodiversity and habitat will be significant. The linkages among these factors and their resultant impact on regional well-being and the global environment need to be much better understood. Consequences of environmental mismanagement are very evident, for example, in areas of the former Soviet Union, where life expectancy has sharply declined over the last decade. We need to begin to take steps to limit the increase in global and regional environmental stresses and to hedge against anticipated adverse consequences.

- <u>The Security Dimension to Environmental Threats</u>. Secretary of State Warren Christopher stated in April 1996: "As we move to the 21st century, the nexus between security and the environment will become even more apparent." Not all environmental issues are security issues, but scarcity and environmental deterioration can fuel old hatreds based on religious, ethnic, or class differences and intensify conflict. Emergent diseases, which can arise and spread from unsanitary, overpopulated regions, are also a security concern. Various regions and environmental stresses leading to or setting the stage for conflict have been the focus of several academic studies of "Environmental Security" over the past decade.

  The subject of environmental security has other facets as well. For example, within the Department of Defense, environmental security is an aspect of preventative defense, intended to create conditions for peace in a region. It entails engaging foreign militaries in environmental collaborations associated with defense activities, acquiring new weapon systems whose day–to–day operations have reduced environmental impact, and working with regional parties to identify sound solutions to regionally troublesome environmental problems. In cases where there is a certain and proximate relationship between the environmental concern and the potential for conflict, the U.S. national security apparatus is much more likely to become engaged. Environmental conditions must also be understood if and when American personnel are committed to overseas activities.

Environmental security—whether it be broadly or narrowly defined—can be a helpful explanatory framework and analytical tool for decision makers, scholars, and the public. It can assist in the conceptualization of problems, the setting of priorities, and the organization of responses to environmental and demographic changes. Over time, it might evolve to become an established discipline in international security, like arms control. There are many parallels between environmental security and arms control. Yet, in the two cases there remain differences in the proximity and immediacy of issues and the clarity of theory and policy strategies: one is a developed field, while the other is still in its infancy.

- <u>The Complexity of Environmental Security Issues</u>. Environment and security issues are multifaceted and complex, in both a cultural and scientific sense. In a fundamental way, environment must be viewed as a strategic factor to be weighed in with many other variables affecting a regional situation. It cannot be considered in isolation as if it were overhead, and it must be worked with full participation of regional entities. Furthermore, global environmental issues must be considered in an international context that has changed significantly in the recent past. In addition to independent states, there are now transnational elites and networks, thousands of intergovernmental organizations, and tens of thousands of nongovernmental organizations (NGOs) that have interest and equity in the international system. These factors raise a broad spectrum of issues related to international agreements, such as accountability, capability overload and congestion, and compliance.

  Any analysis of the Earth system requires a multidisciplinary approach. Modeling must include human, biological, and physical factors. Overall, it is going to be difficult recognizing, defining, and attributing changes in regional and global natural systems—physical, chemical, and biological—to human actions. Linkages are very significant and very complex. The modeler is challenged to identify what factors are most important and to reduce uncertainties in those areas first. This task is made more difficult by the nonlinearity of the overall systems. It is possible a small perturbation due to human actions or random factors can result in a very large effect (e.g., an abrupt change in ocean current that significantly changes global temperatures). In the historic past, a 6° C average temperature drop occurred in northern Europe over a decade.

  In the final analysis, the human factors may be the most difficult to model (and to deal with). An example is provided in the transportation sector. There are many problems associated with transportation, one of which is CO_2 emissions. It is an easy problem to ignore, and we cannot deal with it effectively until we understand underlying sociological factors, such as the coupling between income and mobility. Moreover, within the United States, there presently is no feedback mechanism (social, technical, or economic, such as a gas tax) to stabilize CO_2 emissions. Furthermore, there is no consensus whether or how to approach the issue.

- The U.S. Role in Environmental Security. The United States has the capability to measure, understand, and predict environmental consequences through the application of science and technology. We must influence actions taken in the United States and other industrialized nations that affect the global environment. We must also influence the actions of states with rapidly growing economies, such as China, India, and Indonesia, which will be among the largest economies in the world in the 21st century. China, for example, is a case of rapid economic growth, limited natural resources (both oil and land for agriculture), and a degraded environment that is of international concern. Acid rain from coal burning is a problem for China and for its neighbors. However, there is some good news in this case. China is starting to act to improve its environment at an earlier stage in its economic development than other countries have. With proper management, China may be able to avoid food shortages and major health problems from air pollution in the coming decades.

  In general, the United States has three broad roles to play in the environmental security area. First, we solve problems and share the developed technological capabilities with other countries. An example, currently being worked within the Department of Energy, is a nuclear materials stewardship program. In this effort, technically sound, integrated approaches to managing radioactive materials are being sought, which may engender international cooperation on concepts such as regional storage facilities. Second, we work with other countries to build capacity to prevent environmental stresses. The goal is long-lasting solutions achieved through partnership with host countries. There are academic examples of these activities—humorously portrayed at the workshop as being analogous, at times, to "herding cats." In addition, there are U.S. government activities, such as the Arctic Military Environmental Cooperation effort, where we are engaged with Norway and Russia on spent-fuel disposition and radioactive waste handling issues. Finally, the United States provides direction to international efforts through leadership and example.

- Science and Technology in Response to Environmental Threats. The application and advance of science and technology is crucial to the formulation and execution of responses to environmental threats. Both research universities and national laboratories can contribute to the effort, working in conjunction with private industry and laboratories. Their responsibilities are to develop objective knowledge and technologies. Efforts include analysis, research and testing, and model development for applications ranging from site characterization to global circulation.

  Universities have special responsibilities for the education of the next generation of decision makers, analysts, and scientists; while the Department of Energy laboratories have special responsibilities in the areas of radioactive waste remediation, nuclear safety, and nuclear material handling. In addition, other research institutions (including universities) advance agricultural technologies. These advances will be relied upon to feed a more populous planet in the future. However, grainland under cultivation, per capita water use for irrigation, the size of the fish catch, grazing land, per capita grain yield, and fertilizer use have all leveled off or fallen from peak values during the 1990s. And, agricultural research organizations are not receiving adequate financial support. More support is also needed for many aspects of disease control. Since there is no way to predict when or where the next important new pathogen will emerge, investments are necessary for the various elements of a "discovery-to-control" continuum of activities. Proposals exist to expand activities: a global disease surveillance system, a global diagnostics system, a global emergency response system.

In the area of sensors and global monitoring, the use of intelligence assets and, in the future, high-resolution civilian satellites will provide an ability to understand and respond to humanitarian crises and to monitor flashpoints. Environmental intelligence is now a significant responsibility of the U.S. intelligence community. A Measurements of Earth Data for Environmental Analysis (MEDEA) team, consisting of about 70 scientists, advises the intelligence community on the use of its resources for the study of the environment. MEDEA is also responsible for making data available pertaining to deforestation, change in the temperature of oceans, wetlands management, and radioactive contamination. The intelligence community also works with various agencies on disaster response and monitoring. For the future, NASA has plans for Earth-monitoring satellite systems that will have high spatial and spectral resolution and rapid revisit times.

Remote sensing offers the prospect of supporting a wide range of detailed studies, ranging from issues related to urban areas to aspects of sustainable agriculture. Activities were discussed at the workshop that involved the fusion of various data bases to study the regional consequences of environmental factors which are, in cases, global in origin. The overall objective is to develop multifactoral maps of environmental stress, which can be compared to the regional distribution of various human factors. It might be possible to develop predictive measures for environmentally related security problems. Data is the driver. There is a need for better organization of existing data and the data expected from future sensor systems. The data must be workable, transparent, and accessible. This will facilitate regional cooperation, strengthen policy and regulatory analysis, and foster sustainable use of resources.

- <u>The Future of Environmental Security</u>. The April 1996 statement by Warren Christopher is evidence of high-level Clinton administration interest in environmental security. Significant pronouncements have also been made by John Deutch (as director of Central Intelligence) and Secretary of Defense William Perry. In addition, memoranda of understanding exist among various departments and agencies fostering cooperation on environmental security issues. This high level interest provides a basis for work projects at various levels within DoD, DOE, the State Department, and the Environmental Protection Agency.

Yet, there are two related sources of concern. First, as expressed by one workshop participant, “If everyone owns the problem, no one owns the problem.” If there are shared interests in environmental security, it is important that responsibilities are carefully delineated and that vital aspects of the research, development, and execution responsibilities do not fall through the cracks; alternatively, responsibility could be delegated to one central entity, but there are problems with that approach also. Second, a combination of federal budget pressures, a lack of immediacy, and an absence of sharp focus to environmental security activities can lead to systemic under investment. We will soon see what momentum environmental security has in the second Clinton administration.

In a much broader sense, it may take several administrations after the end of the Cold War to readjust priorities and realign the direction of the national security apparatus in the U.S. government. Environmental security may take time to mature into a well-funded thrust area. Alternatively, the evolving new relationship between humans and the natural environment might broaden to become a principle of basic quality of life worldwide—a theme much broader than environmental security. What are our overall responsibilities to all the citizens of Earth and to future generations?

Part two: Policy development

Environment and security

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"As we move to the 21st century, the nexus between security and the environment will become even more apparent." So said former Secretary of State Warren Christopher (1996) following his April 1996 announcement of the State Department's unprecedented initiative to put environmental issues near the top of the foreign policy agenda.[1] Coming from a veteran foreign policymaker with little environmental background, Christopher's speech raised hopes among many environmentalists that U.S. foreign policy was finally embracing a principle long espoused by environmental and population experts: namely, that the unprecedented pace and scale of population growth, resource depletion and global environmental change demand a redefinition of security. But to many foreign policy experts inside and outside the State Department, raising the profile of international environmental issues now—at a time of diminishing budgets and declining public and congressional interest in foreign affairs—seemed a dangerous distraction. Furthermore, characterizing environmental issues as security issues struck others as inappropriate and analytically muddled.

The number of U.S. government and scholarly endeavors incorporating the environment and security (or "environmental security") theme is proliferating—in large part because of the intellectual substance underlying the ideas, but in part too because this alluring, catch–all concept engages the concerns and interests of an array of actors and institutions.[2] Many senior figures in the Clinton administration have embraced environment and security ideas. While these ideas have not produced a common policy agenda or focus, numerous rhetorical statements and government initiatives considering the environment in the context of U.S. security interests have appeared since 1993.[3]

Foci of environment and security conceptions differ on what is being secured (what is the object of security), what is being secured against, who is trying to provide security, and what methods are being employed to provide security. Key differences arise among the *goals* sought by various institutions and policies. Some efforts are fundamentally geared towards broad sustainable development goals to address the root *causes* of environmental problems and enhance human, economic, and international security. Others, are focused on preventing or containing specific threat or *symptoms* of environmental problems to protect more traditional national security interests. Similarly, observers disagree over the appropriate institutions, tools, and *means* actors should use to construct solutions. In some cases, policy responses include methods and goals that are sometimes at odds with one another if not mutually exclusive.

Yet despite its perceived shortcomings, the environment and security framework offers a new explanatory and analytical tool to help decision makers, scholars and the public conceptualize problems, set priorities and organize responses to a range of environmental and demographic changes that will increasingly demand attention. The following is an overview of the major scholarly arguments and U.S. government activities to date concerning environment and security ideas.[4, 5] This broad ranging treatment is intended to provide a baseline for discussions. Given this wide scope, no one academic argument or policy manifestation is treated with the attention each individually deserves. We divide the field into three main categories: (1) debates regarding environment and new definitions of security, (2) debates regarding environment and traditional definitions of security, and (3) debates regarding how security institutions affect the environment. Within each of these categories, we detail arguments from what we loosely refer to as the proponents and critics of the various conceptions. It should be emphasized that considerable diversity in opinion persists both within and among these three categories regarding the degree of "threats" and the prioritization of issues.

Debates on the environment and new definitions of security

Proponents linking environmental problems to nontraditional security concerns tend to reject the state-centric and militarized definitions of security that dominated security studies during the Cold War. They support more holistic or "redefined" conceptions of security that extend beyond protecting the state from external aggression, arguing that global, regional, and local environmental problems seriously threaten human health and well-being and/or economic security.[6] According to this line of thinking, it is in the common interest of all actors, not merely states, to guard against environmental degradation for the same reason they must protect against organized violence: because both have the potential to harm human, material, and natural resources on a potentially large and disruptive scale.[7]

Citing human health concerns, proponents argue that ozone layer depletion, for example, will lead to a marked increase in certain cancer rates as a result of increased exposure to ultraviolet radiation. Similarly, global warming may create conditions more conducive to the spread of infectious diseases.[8] As temperatures and weather patterns change, certain species that are vectors for disease may multiply and/or migrate—spreading tropical diseases like dengue fever and malaria to previously unaffected areas. Similarly, local environmental problems, like arable land and fresh water scarcity, forest destruction, and the spread of pollution can lead to high incidences of sickness, malnutrition, and mortality.[9] Even the loss of biological diversity is cited as a development that will erode gradually the health and well-being of individuals and national economies. As the world loses more species, humans also lose part of the important genetic library available for scientific research—and therefore preclude potential discoveries of life-saving drugs, new agricultural crops, and ways to counter human-induced ecological changes.

Environmental problems are also believed to threaten economic security. If a country does not manage its forests sustainably, for example, it could do more than just lose an important part of its export base. It could also begin to experience changes in local climate, increased flooding, and siltation problems that would degrade arable land, decimate fisheries, and severely restrict the navigability of important waterways. Any and all of these problems could require huge economic adaptation costs, assuming that meaningful adaptation is itself possible. Environmental problems may also impose burdensome, sometimes crippling, retroactive expenditures as nations grapple with actual or potential disasters connected to the inadequate handling of chemical, nuclear, and other toxic materials. Similarly, countries adapting to climate change may be saddled with enormous costs to address future problems associated with more frequent and intense weather events, rising sea levels, salt water intrusion, and fundamental changes in agricultural systems.

Some proponents believe that framing environment and population issues as security issues—and raising international awareness of environmental "threats"—may prompt collective solutions, better compliance with international environmental agreements, and improved relations between groups and nations. Environment and security rhetoric may also generate the widespread domestic public support, funding, and action-oriented responses necessary to achieve sustainable development and population goals. Early writings in particular employed this rhetoric explicitly to gain support and reorder priorities.

Critics of redefining security to include the environment do not often dispute the important connections between environment, health, and economics. They disagree, however, with the characterization of environmental, social, and economic issues as security concerns, and argue that environmentally related health and well–being issues are fundamentally different from military threats. Critics express concern about categorizing these issues as "threats," since they are fundamentally different than military ones. Both kill people, but grouping such phenomena as disease and natural disasters under the term security is conceptually muddled (Deudney 1990, 461-476; Deudney 1991, 23-28). Military threats are most often targeted and intentional, two characteristics not commonly associated with environmental problems. Traditional military threats typically present an immediacy of danger in the form of direct violence. Environmental "threats" are often, but not always, manifested over longer and incremental time scales and therefore differ fundamentally in how they should be addressed. With these differences in mind, the addition of such a diversity of "threats" to security makes the concept boundless and therefore considerably less useful as an analytical tool.[10]

Critics also raise the concern that combining environment and security will have the unintended and inappropriate "securitizing" of environmental issues. [11] Expressing a pessimism about the ability to change existing security institutions and mind-sets, these observers think a militarization of approaches to the environment is more likely than a greening of security. According to this perspective, specific departments and agencies (and environmental nongovernment organizations [NGOs]) are employing the honorific term of "security" only to win more attention and funding for environmental priorities (Deudney 1991; Levy 1995a and 1995b). Therefore the receptivity of traditional security structures—including the Department of Defense (DoD), Department of Energy, and the intelligence community—to new green missions represents a classic bureaucratic politics effort to retain comparable budgetary outlays and to derive public relations benefits (Finger 1991).

Furthermore, critics maintain that framing these environmental issues as security issues could damage relations among groups and states. Environment and security rhetoric focuses disproportionate attention and blame for environmental problems on the developing world. The spotlight on the global South de facto diverts attention and responsibility away from the central role played by northern development and consumption practices in the environmental problematique. Environmental problems are characterized as "threats" from outside, providing an "us" versus "them" perspective that reinforces rather than breaks down North–South divisions. This interpretation limits the appeal of the environment and security paradigm. Other observers fear that environment and security ideas will simply provide another justification in a long line of historical excuses for developed countries to infringe upon the sovereign rights of weaker developing nations (Deudney 1990 and 1991; Saad 1991; Conca 1994).

Because the scope of this conception of environment and security is so broad, U.S. policymakers have been unable, or unwilling, to agree on a cohesive, overarching environment and security policy or plan. Many agencies and departments, however, have used environment and security arguments or terminology to explain activities or raise the profile of international environmental concerns.

The Clinton administration's early decision to elevate environmental issues in policy making, for example, led to the creation of several high-level positions in more traditionally focused bureaucracies, including a senior director post for global environmental affairs at the National Security Council in early 1993, an office of the deputy under secretary of defense for environmental security in early 1993, an office of the under secretary of state for global affairs in early 1993, and a national intelligence officer for global and multilateral issues at the National Intelligence Council in late 1993.[12]

The first formal interagency mechanism on environment and security was established in July 1996 through a memorandum of understanding (MOU) on environmental security between the Departments of Defense and Energy, and the Environmental Protection Agency. The MOU states that "threats to environmental quality affect broad national economic and security interests, as well as the health and well-being of individual citizens" and sets forth a framework to strengthen coordination of efforts on a broad range of scientific and technical topics.[13] In addition, the 1996 State Department initiative to integrate environmental concerns throughout U.S. foreign policy has been justified in part by environment and security arguments, but has been framed more broadly in terms of U.S. national interests.[14]

Debates on environment and traditional definitions of security

A second set of arguments surrounding the environment and security fits more easily into the traditional security discourse. At the center of the debate is the assertion that local and regional environmental degradation and/or resource scarcity (exacerbated by population pressures, wealth distribution, and global environmental changes) may be an important contributing factor to political instability and/or violent conflicts. Because of the daunting rate and scale of environmental and population change, the cases of environmentally related strife and instability are expected to proliferate in the coming decades—leading to more subnational conflicts reminiscent of Somalia, Haiti, Rwanda, and Burundi that demand U.S. attention. Some argue that environment and population forces will be key determinants in the political and economic success or failure of nations that are geostrategically important to the United States.[15] The result of further environmental degradation and resource scarcity may be a more unstable and "chaotic" international system—the effects of which may extend beyond national borders.

In recent years, researchers have investigated connections between environmental stress and conflict. In case studies, scholars have shown that scarcities of basic renewable resources—like cropland, water, fish, and forests—can harm economic productivity and overwhelm a state's capacity to provide citizens with basic needs. Environmental scarcities can also seriously deepen poverty, exacerbate divisions between the haves and the have-nots, and lead to population movements. These negative effects can, in turn, be the underlying cause of "subnational," "diffuse," and "persistent" conflict taking the form of ethnic or relative deprivation clashes due to environmentally induced population growth movements and civil strife.[16] Such conflicts have the potential to contribute to a state's fragmentation or, conversely, to its authoritarian "hardening." The same research suggests that global issues such as climate change and ozone depletion will exacerbate local and regional scarcities, but are unlikely to make significant contributions in and of themselves to conflict in the coming decades.

The leading researchers on this topic are often quick to emphasize that renewable resource scarcities are more likely to cause conflicts and violence within countries than between nations—with the possible exception of situations involving shared wa*ter* resources (the Middle East being a prime example).[17] Others argue that even if they do not provoke large-scale military conflicts, dwindling natural resources shared among nations will at the very least be a significant source of continued diplomatic tensions and episodic outbreaks of violence, as illustrated by the 1995 diplomatic crisis between Canada and Spain over Spanish fishing off the Grand Banks and similar fishing disputes between Japan and its neighbors.

Some critics believe that shared environmental problems are less likely to cause conflicts than to defuse them. They argue that shared environmental problems prompt collective action that, in turn, may generate goodwill and trust among disputing groups and thereby defuse tensions that could lead to conflict. Other critics assert that environmental scarcity does not produce a unique form of conflict and demonstrates little propensity to contribute to *inter*-state conflicts (Lipschutz and Holdren 1990). The environmental variable therefore does not carry as much priority because it is less likely to relate to the traditional academic and policy focus on state-to-state conflict.

Beyond this lower prioritization, cases in which the environment is assigned a role in *intra*-state conflict are sometimes dismissed because the environment–conflict relationship is said to be spurious. Antecedent political and economic variables more likely represent the necessary and sufficient conditions that are responsible for the conflict. Critics believe their arguments are strengthened by the fact that some environment and conflict researchers have been unable, or unwilling, to assign a relative weight to the environmental variable in conflict formation. The almost exclusive focus on cases from the developing world has raised methodological questions such as case selection bias. Before conclusions can be drawn about the causal role of the environment in conflict, research must explain cases in which environmental scarcities are present but violent conflict does *not* occur. Critics also cite the need to incorporate environmental variables into larger studies of conflict rather than focusing first and foremost on the environmental variable in individual case studies (Levy 1995a, 1995b). Aside from the importance of other political and economic variables, the argument is made that the interdependent international trading system, coupled with technological substitutes, will ameliorate serious resource shortages that could contribute to conflicts (Deudney 1991).

Relative to other conceptions of environmental security, the academic literature on environment and conflict linkages is arguably the most developed. It has also received the most sustained attention by policymakers and a broader group of scholars, perhaps in part because it easily fits into predominant state-centered views of security. The connections between environmental problems and international stability were formally recognized in the U.S. National Security Strategy beginning in 1991, with additions in subsequent years (Butts 1994).[18] In late 1993, following a briefing by Thomas Homer-Dixon of the University of Toronto at the National Security Council (NSC), the NSC global environmental affairs directorate and the office of the deputy under secretary of defense for environmental security began to incorporate environment and conflict ideas into their work. Previously, the DoD environmental security office had focused almost exclusively on addressing the toxic legacy of past, current, and future military activities. The publication of journalist Robert Kaplan's (1994) article "The Coming Anarchy" in *The Atlantic Monthly* **—**which identified "the environment" as "*the* national-security issue of the early 21st century"**—**played a catalytic role in bringing the environment-conflict thesis to the highest levels of the Administration and the larger Washington policy community.

Numerous statements have since been made by Clinton administration officials—including the president, the secretary of state, the director of central intelligence and the deputy under secretary of defense for environmental security—identifying the environment as a contributing factor to conflict and instability.[19] These statements have been accompanied by numerous related government activities. One of the first such initiatives was the commissioning in fall 1994 of a panel of scholars known as the Task Force on State Failure to examine the historical conditions most closely associated with "state failures," including environmental and demographic factors.[20] DoD joined with NATO partners in 1995 through the Committee on Challenges to a Modern Society to launch a pilot study on "Environment and Security in an International Context"; the study will "assess security risks posed by environmental problems, prioritize those risks for action, and devise an action plan to address them—with a strong emphasis on preventive actions."(Goodman 1996)[21]

Also in 1994, the office of the deputy under secretary of defense for environmental security began to play a key role in generating interest and cooperation among many agencies and departments on these and a wide range of other environment and security issues. It co-organized with the intelligence community the first major interagency conference in June 1995 on "Environmental Security and National Security," which heightened government interest in these topics and inspired a range of follow-up activities. Among them was the previously mentioned joint 1996 DoD-DOE-EPA memorandum of understanding on environmental security, which reflected these agencies' interest in addressing a broad set of environmental concerns—including those that could contribute to instability. In recent months, senior DoD officials have characterized the environment as a "key component" of its strategy of preventive defense. They argue that if the U.S. military engages on international environmental issues—identifying problems, addressing them early enough to make a difference, and promoting cooperation with other nations' militaries on environment—it will help to build trust and understanding, forge new partnerships, and promote democracy abroad (ECSPR 1995; Goodman 1996).[22]

Below the level of top leadership, there is evidence that some environment and security concepts are being integrated into traditional security institutions. Increasingly, analysts within military and intelligence institutions are adding environmental factors to the list of variables they consider when anticipating coups, political instability, mass migrations, and violent conflict. Director of Central Intelligence John Deutch (1996) stated that analysts must take into account the "essential connection between environmental degradation, population growth, and poverty" because "environmental factors influence the internal and external political, economic, and military actions of nations important to our national security." These factors are considered important by some military planners who want to anticipate situations in which the U.S. military might be asked to intervene.[23]

Debates regarding how security institutions affect the environment

Debates on how security institutions affect the environment invert the environment and security causal relationship; they do so by arguing that security institutions, like the military and the intelligence communities, can dramatically affect the environment—in either a harmful or a beneficial way. One argument is that the military and intelligence communities have unique and powerful capacities to help analyze, predict, and ameliorate international environmental problems. These include monitoring and enforcing international environmental agreements; gathering, analyzing, and disseminating scientific data on the natural environment; responding to mitigate environmental crises and disasters; providing technical expertise to other nations' militaries; implementing environmental sustainability programs; guaranteeing access to natural resources; spinning off environmental cleanup technologies; and protecting natural parks and reserves.[24] The intelligence community offers environmental monitoring capabilities and multidisciplinary analytical tools to integrate environmental factors into complex political and economic assessments. Similarly, the Defense Department has publicly raised the priority of environmental compliance and restoration within its ranks, and it has sought to share its specialized knowledge and experience with other nations' militaries on resource management and pollution cleanup and prevention. Given DoD's enormous holdings of land worldwide and vast network of foreign military contacts, the military wields considerable control over the natural environment both within and outside of the United States.

An alternative perspective focuses on the deleterious environmental effects of military operations and war-fighting.[25] Based on this record of incurring environmental damage, some argue that the tangible and theoretical instruments of traditional security conceptions should be excluded from playing a role in addressing environmental problems. The military should be viewed as part of the problem, not part of the solution.

Critics also maintain that the conflictual orientation of national security makes the military and intelligence tools—designed to safeguard the state—inappropriate for addressing transnational environmental problems. The capabilities of the conflictual and secretive security structure are mismatched with the cooperative and transparent responses deemed most appropriate for addressing environmental threats. Finally, from a more traditional security perspective, some argue that the armed forces should not sacrifice operational readiness for involvement in nontraditional activities like environmental protection. Time and resources utilized to monitor environmental treaties or perform other environmental tasks detract from the military's primary war-fighting mission(Deudney 1990; Finger 1991; Dalby 1992; Butts 1994).[26]

In addition to DoD activities concerning environment and conflict links, the DoD environmental security office has viewed environmental compliance and environmental restoration as central missions. These efforts have been pursued most visibly through the Defense Environmental Restoration Account (DERA), comprising over one-fifth of the approximately $5 billion annual DoD environmental security budget (down from approximately $6 billion in fiscal year 1994). This account is targeted largely at cleanup of the toxic legacy of military activity on and around bases. International programs include cooperative military-to-military partnerships for radiological pollution and military base cleanup. Examples of cooperative arrangements include a study on cross-border contamination in the Arctic (United States, Norway, and Russia), a study on reuse of military land conducted by the NATO Committee on the Challenges of Modern Society, and a cooperative project to decommission the Paldiski naval reactor training facility (Estonia, Russia, and the United States).[27] The agencies involved in the previously mentioned 1996 MOU on environmental security are already engaged in similar joint efforts in Russia and the Baltic region.

Many other major policy initiatives related to this conception originated in Congress. Former Senators Al Gore (D-TN) and Sam Nunn (D-GA) successfully obtained congressional funding in 1991 for what became known as the Strategic Environmental Research and Development Program (SERDP).[28] With the three goals of environmental compliance, environmental restoration, and data gathering and analysis, this multiyear program was designed to help clean up the toxic legacy of past U.S. military activities, make ongoing and future U.S. military activities less toxic, and provide retrospective data for environmental study.

Regarding environmental monitoring issues, former Senator Al Gore in 1991 also engineered the release of Navy ice-pack thickness data to scientists studying climate change in the Arctic Basin (Gore 1991). The subsequent efforts to routinize the release of Navy data led to the creation of a task force of scientists and CIA officials to examine whether the intelligence communities assets could be turned to the threat of environmental degradation. An Environmental Task Force (ETF) of 70 scientists— now known as the MEDEA Group—was tasked with examining retrospective data and conducting experiments to test the applicability of intelligence systems for environmental science.

One outgrowth of Gore's efforts and the MEDEA group has been an effort to convince the Russian military and environmental agencies that they should conduct a similar effort. A multiday conference in May 1995 produced a memo of understanding for future cooperation and provided the Russians with a model of how the Americans have proceeded; special attention was paid to remote sensing and other observation data that could be declassified and released for environmental study. Follow-up has occurred at meetings of the U.S.–Russian Joint Commission on Economic and Technical Cooperation created in 1993, colloquially known as the "Gore-Chernomyrdin Commission."

The intelligence community has begun to formalize what were previously ad–hoc attempts to release data and share it with environmental scientists. In February 1995, Vice President Gore announced the declassification of 860,000 spy-satellite photographs taken between 1960 and 1972. This release had been recommended to the White House by the CIA's Classification Review Task Force that, in turn, had been led by the Central Imagery Office and the Environmental Task Force. In addition, MEDEA is working with the intelligence community to establish a "Global Fiducials Program" that will direct existing satellites to monitor certain environmentally sensitive areas around the world. Director of Central Intelligence John Deutch described the program in a major 1996 speech on the environment, explaining that it would both greatly benefit science and provide "strategic warning of potentially catastrophic threats to the health and welfare of our citizens."[29]

The intelligence community is also playing a role in monitoring other nations' compliance with environmental agreements. This monitoring employs some of the same remote sensing capabilities that are currently utilized by the military to verify arms control agreements and nonproliferation pledges. The CIA is working with EPA to combat the black market trade in ozone-destroying chlorofluorocarbons (CFCs), which are being phased out under the Montreal Protocol (1987), and other subsequent amendments to the Vienna Convention of 1985. The U.S. intelligence community also participates in monitoring illegal drift net fishing and signatories' compliance with the Montreal Protocol.[30] Military and intelligence assets are also being used to react to immediate humanitarian crises that have environmental components—including "natural" and technological disasters. The Defense Intelligence Agency attempts to provide "environmental defense intelligence" that includes warning of where disasters may happen and background information for responding forces when disasters occur (Constantine 1995). This intelligence could enhance U.S. security interests by helping to avert regional instability by providing prompt humanitarian relief.

Conclusion

This overview should underscore the fundamental point that environment and security views ultimately depend upon geographic perspective and institutional affiliation. Developed countries are more likely to think of environment and security in terms of global environmental changes and the potential for instability and conflict in geostrategically important areas, while developing countries tend to be more concerned with the human security implications of local and regional problems. The diversity of views, potential for misunderstandings, and vagueness of terms should encourage many scholars and analysts to improve the clarity of their arguments and terminology in their written work.

Whether one agrees or disagrees with specific arguments, environment and security writings, rhetoric and activities—which are often accompanied by sobering statistics and trenchant analyses of environment and population dynamics—have significantly raised the profile of many environmental concerns. They have also generated many useful discussions and new ways of thinking among a diverse set of experts, including those who previously considered the environment peripheral or unimportant to their interests.

At the same time, there are serious limitations to the environment and security conceptual and linguistic framework. As convincing as certain security-related arguments may be, they are not the only reasons why the American public, decision makers and other nations should care about the environment. Falling outside the environment and security framework, even when broadly conceived, are value-oriented considerations about the aesthetics of nature, human responsibility for global stewardship, and environmentally induced humanitarian concerns. These considerations can greatly enhance the process of formulating effective solutions and winning sustained public attention and support for international environmental action.

Policymakers might therefore be best served by framing international environmental priorities in terms of a broad set of interests, including but not limited to security concerns. They should also resist the temptation, common among security analyses, to examine environmental problems solely in terms of crises and "threats." Threat-based analyses, while helpful in setting priorities, can have the unintentional effect of encouraging decision makers to pay attention to issues only when there are imminent crises—at which time it is often too late for effective interventions and corrective measures. The focus on threats may also distract decision makers' attention away from other important incremental environmental changes that, if not addressed, would become equally serious problems in the aggregate. Examining how environmental preservation will enhance security and other interests over time, might lead decision makers to adopt more appropriate long-term strategies that address the underlying causes of problems.

International environmental issues will be most effectively addressed in the decades ahead through a combination of conceptual clarity, a pragmatic and multidisciplinary approach to problem solving, an emphasis on long-term strategies, and a willingness and improved ability among leaders to explain the complexity associated with environmental change. As the debates on environment and security continue, environmentalists' arguments will be strengthened if they resist the temptation to place all their priorities under the attention-grabbing security rubric. Meanwhile, skeptical foreign-policy experts will benefit from recognizing the complexity of environmental systems and their relevance to many critical interests. As the United States considers security expenditures and priorities for the 21st century, the vibrant debates concerning environment and security matters will continue to be instructive.

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Endnotes

1. For related statements by Christopher, see the 1996 *Environmental Change and Security Project Report* (ECSPR). Washington, DC: Woodrow Wilson International Center for Scholars. 1996(2):77-85.

2. To avoid unintentionally promoting a term that still lacks a common definition, we minimize the use of the term "environmental security" throughout this overview.

3. See excerpts of official U.S. government documents and statements in the 1995 and 1996 *ECSPRs.* 1995(1): 47-59 and 1996(2): 72-78.

4. The scholarly literature offers a surprisingly small number of significant literature reviews or edited volumes reflecting different authors' perspectives. Most significant are: Renner, Michael. 1992. National Security: The Economic and Environmental Dimensions. *Worldwatch Paper No.89*. Washington, DC: Worldwatch Institute; Dalby, Simon. 1992. Security, Modernity, Ecology: The Dilemmas of Post-Cold War Security Discourse. *Alternatives* 17 (1), 95-134; Matthew, Richard A. 1995. Environmental Security: Demystifying the Concept, Clarifying the Stakes. *ECSPR*. 1995(1):14-23; Dabelko, Geoffrey D., and David D. Dabelko. 1995. Environmental Security: Issues of Conflict and Redefinition. *ECSPR.* 1995 (1): 3- 13; Dokken, Karin, and Nina Grœger. 1995. The Concept of Environmental Security—Political Slogan or Analytical Tool? *International Peace Research Institute Report.* Oslo: International Peace Research Institute. See also: Jyrki Käkönen, ed. 1994. *Green Security or Militarized Environment*. Brookfield: Dartmouth Publishing Co.; and Deudney, Daniel, and Richard A. Matthew. Forthcoming. *Contested Ground: Security and Conflict in the New Environmental Politics*. Albany: SUNY Press. For more comprehensive bibliographic guides to the literature, see issues 1 and 2 of the *ECSPR* 1995(1): 92-105; 1996(2): 153-160 .

5. The relatively few broad, orienting writings in the literature are supplemented by ongoing contributions from parallel projects. Some projects have produced original research, particularly investigating connections between environment and conflict. These include: the Project on Environment, Population and Security, headed by Thomas Homer-Dixon and co-sponsored by the University of Toronto and the American Association for the Advancement of Science; the Environment and Conflicts Project (ENCOP), a joint project of the Swiss Federal Institute of Technology and the Swiss Peace Foundation; and a large number of Nordic research institutes and university departments. Other projects provide fora for academic and policy discussions and publications and/or plans to do research. These include the Woodrow Wilson International Center for Scholars' Environmental Change and Security Project; the International Institute for Environmental Strategies and Security headquartered at Laval University in Quebec; the International Human Dimensions of Global Change Programme Research Project on Global Environmental Change and Human Security; the Center for Environmental Security at Battelle National Laboratory; and the Stanford University Institute for International Studies.

6. See Brown, Lester. 1977. Redefining Security. *Worldwatch Paper No. 14* Washington, DC: Worldwatch Institute; Ullman, Richard H. 1983. Redefining Security. *International Security* 8. Summer: 129-153; World Commission on Environment and Development. 1987. Peace, Security, Development and the Environment. *Our Common Future.* New York: Oxford University Press: 290-307; Mathews, Jessica Tuchman. 1989. Redefining Security. *Foreign Affairs* 68 Spring: 162-177; Mische, Patricia M. 1989. Ecological Security and the Need to Reconceptualize Security. *Alternatives* (Vol. 14, No. 4): 389-429; Myers, Norman. 1989. Environment and Security. *Foreign Policy* 74 Spring: 23-41; Myers, Norman. 1993. *Ultimate Security: The Environmental Basis of Political Stability*. New York: W.W. Norton & Co.; Gore, Al. 1990. SEI: A Strategic Environment Initiative. *SAIS Review* 10 Winter/Spring; Porter, Gareth. 1995. Environmental Security as a National Security Issue. *Current History* 94 May: 218-222; Renner, Michael. 1989. "National Security: The Economic and Environmental Dimensions." Worldwatch Paper No. 89. Washington, DC: Worldwatch Institute. Renner, Michael. 1996. *Fighting for Survival: Environmental Decline, Social Conflict, and the New Age of Insecurity.* New York: W.W. Norton and Co.); United National Development Programme. 1994. Redefining Security: The Human Dimension. *Human Development Report.* Oxford: Oxford University Press. See also: public statements by Clinton Administration officials excerpted in the 1994 and 1995 ECSPRs.

7. For an elaboration on this point and a discussion of the "redefining security" literature, see Del Rosso Jr., Stephen J. 1995. The Insecure State. *Daedalus* 124 (2): 175-207.

8. See Pirages, Dennis. Microsecurity: Disease Organisms and Human Well-Being. *The Washington Quarterly.* Fall 1995.

9. See Feshbach, Murray, and Alfred Friendly, Jr. 1992. *Ecocide in the USSR: Health and Nature Under Siege*. New York: Basic Books.

10. Deudney, 1990. Deudney 1991. Walt, Stephen M. 1991. In The Renaissance of Security Studies. *International Studies Quarterly* 35 (2): 211-23; Dalby, 1992. Conca, Ken. 1994. In the Name of Sustainability: Peace Studies and Environmental Discourse. *Peace and Change* 19 (2): 91-113; Wœver, Ole. 1995. Securitization and Desecuritization. *On Security*. Ronnie D. Lipschutz, ed. New York: Columbia University Press, 46-86; Lipschutz, Ronnie D. 1995. On Security. *On Security*. Ronnie D. Lipschutz, ed. New York: Columbia University Press, 1-23; Levy, Marc A. 1995a. Time for a Third Wave of Environment and Security Scholarship? *The Environmental Change and Security Project Report*.. Washington, D.C.: Woodrow Wilson International Center for Scholars, 44-46; Levy, Marc A. 1995b Is the Environment a National Security Issue? *International Security* 20 (2): 35-62; Keller, Kenneth H. 1996. Unpackaging the Environment. *World Policy Journal* 13 (3), 11-23.

11. See Deudney 1991; Dalby 1992; Conca 1994; Wœver and Ole 1995.

12. Other offices engaged in environment and security-related analyses or programs include: the Office of the Assistant Secretary of State for Oceans and International Environmental & Scientific Affairs (OES); Department of Energy Office of National Security/

Environmental Security; Environmental Protection Agency's International Activities office; Office of Science & Technology Policy; National Oceanic and Atmospheric Administration; and the Agency for International Development. See *ECSPR* 1995 and 1996 for summaries of State Department and other government activities relating to environment and security.

13. Memorandum of Understanding Among the U.S. Environmental Protection Agency, the U.S. Department of Energy, and the U.S. Department of Defense Concerning Cooperation in Environmental Security, July 3, 1996. Cooperative activities under the MOU include "information exchange, research and development, monitoring, risk assessment, technology demonstration and transfer, training, emergency response, pollution prevention and remediation, technical cooperation, and other activities concerned with radioactive and nonradioactive contamination and other adverse environmental impacts on terrestrial areas, the atmosphere, hydrosphere, cryosphere, the biosphere (including human health) and the global climate system; defense or defense (strategic) industrial activities, energy production, supply and use, and related waste management."

14. Representative remarks by Warren Christopher include the following: "The environment has a profound impact on our national interests in two ways: First, environmental forces transcend borders and oceans to threaten directly the health, prosperity and jobs of American citizens. Second, addressing natural resource issues is frequently critical to achieving political and economic stability, and to pursuing our strategic goals around the world." Deputy Secretary of State Strobe Talbott later said that environmental problems are "a threat to us, to our country, our health, our prosperity, our way of life: in short, our national interest." He added that other nations' "struggles over land, water, and other natural resources can lead to instability in regions of critical importance to the United States." See Christopher, Warren, April 9, 1996; Talbott, Strobe, Deputy Secretary of State, "The Global Environment and the National Interest," Speech at the Foreign Service Institute, September 10, 1996

15. See Chase, Robert S., Emily B. Hill, and Paul Kennedy. 1996. Pivotal States and U.S. Strategy. *Foreign Affairs* 75 (1): 33-51. The authors argue that environmental and demographic forces will be fundamentally important to the futures of important "pivotal states," including Egypt, Turkey, Mexico, India, and Indonesia.

16. See: Homer-Dixon, Thomas F. 1994. "Environmental Scarcities and Violent Conflict: Evidence from Cases." *International Security* 19 (1): 5-40; Homer-Dixon, Thomas F. 1991. On the Threshold: Environmental Changes as Causes of Acute Conflict. *International Security* 16 (3): 76-116. See also: Durham, William H. 1979. *Scarcity and Survival in Central America: Ecological Origins of the Soccer War*. Palo Alto, Calif.: Stanford University Press; Gurr, Ted Robert. 1985. On the Political Consequences of Scarcity and Economic Decline. *International Studies Quarterly* (29): 51-75; Mathews, 1989. Westing, Arthur H., ed. 1986. *Global Resources and International Conflict*. Oxford: Oxford University Press, 204-210; Byers, Bruce. 1991. Ecoregions, State Sovereignty and Conflict. *Bulletin of Peace Proposals* 22 (1): 65-76; Gleick, Peter H. Environment and Security: The Clear Connection. *Bulletin of the Atomic Scientists. April* 1991, 17-21; Gleick, Peter H. 1993. Water and

Conflict. *International Security* 18 (1): 79-112; Molvær, Reidulf K. 1991. Environmentally Induced Conflicts?: A Discussion Based on Studies from the Horn of Africa. *Bulletin of Peace Proposals* 22: 175-188; Libiszewski, Stephan. 1992. What is an Environmental Conflict? Occasional Paper No. 1 of the Environment and Conflicts Project. Swiss Peace Foundation and Center for Security Studies and Conflict Research. Bern and Zurich, Græger, Nina, and Dan Smith, eds. 1994. *Environment, Poverty and Conflict*. Oslo: International Peace Research Institute. It is important to note that not all environment and conflict researchers present their findings or ideas in the context of environment and security.

17. See Homer-Dixon, 1991, 1994. Arthur Westing maintains, however, that at least 12 inter-state conflicts in the 20th century contained distinct and significant resources components. Westing, 1986.

18. See *ECSPR*, 1995, 1996 for detailed discussion and quotation of the evolving U.S. National Security Strategy.

19. For excerpts of speeches by these officials and others including the Administrator of the Agency for International Development and the Under Secretary for State for Global Affairs, see the *ECSPR*, 1995:47-58, and 1996:72-77. Most recently, see Deutch, John, Director of Central Intelligence, The Environment on the Intelligence Agenda, speech at the World Affairs Council in Los Angeles, July 25, 1996; Talbott, Strobe, September 10, 1996; and Goodman, Sherri Wasserman, Deputy Under Secretary of Defense for Environment and The Environment and National Security, speech at the National Defense University, August 8, 1996. One such excerpt comes from President Clinton's June 19, 1994, remarks to the National Academy of Sciences:

> ...[W]hen you look at the long-run trends that are going on around the world—you read articles like Robert Kaplan's article in *The Atlantic* a couple of months ago that some say it's too dour...you could visualize a world in which a few million of us live in such opulence we could all be starring in nighttime soaps. And the rest of us look like we're in one of those Mel Gibson "Road Warrior" movies...I was so gripped by many things that were in that article, and by the more academic treatment of the same subject by Professor Homer-Dixon...

20. For a description of the activities of the Task Force on State Failure, see the *ECSPR*, 1995: 80.

21. For other DoD activities, see the *ECSPR*, 1995: 80.

22. For other DoD activities, see the *ECSPR*, 1995: 80.

23. See Deutch speech on July 25, 1996.

24. See Butts, 1994. Funke, Odelia. 1994. Environmental Dimensions of National Security: The End of the Cold War. *Green Security or Militarized Environment*. Jyrki Käkönen,

ed. Brookfield: Dartmouth Publishing Co., 55-82. Also Fleishman, Rachel. 1995. Environmental Security: Concept and Practice. *National Security Studies Quarterly* 1 (2).

25. See Ehrlich, Anne H., and John W. Birks, eds. 1990. *Hidden Dangers: Environmental Costs of Preparing for War.* San Francisco: Sierra Club Books. The intentional modification of the natural environment as an instrument of war—and potential for "eco-terrorism"—is another grouping of issues sometimes considered under environment and security. In the recent historical context, the use of chemical defoliants and weather modification techniques in Southeast Asia in the 1960s and early 1970s helped give rise to the Convention on the Prohibition of Military or Other Hostile Use of Environmental Modification Techniques (ENMOD) banning such practices. The Iraqi sabotage of Kuwaiti oil facilities in the 1991 Persian Gulf War presented the U.S. military with a mission that involved using force to counter an environmental threat. Reacting to mitigate the symptoms of environmental catastrophe, the U.S. Air Force successfully deployed fighter planes to stem the international flow of oil into the Persian Gulf. For guidance to the body of literature in this area, see: Westing, Arthur H. 1994. *Environmental Warfare*. London: Taylor and Francis, Westing, 1986; Westing, Arthur. 1988. *Cultural Norms, War and the Environment.* Oxford: Oxford University Press; and Westing, Arthur. 1990. *The Environmental Hazards of War: Releasing Dangerous Forces in an Industrialized World.* Newbury Park, CA: Sage.

26. See *Green Security or Militarized Environment*. Jyrki Käkönen, ed. Brookfield: Dartmouth Publishing Co., 83-110; Conca, 1994; Lipschutz, 1995; and Wœver, 1995.

27. See *ECSPR*, 1995: 83; Department of Defense. 1995. "Report on a Joint U.S.-Russia Ecological/Environment Seminar." Washington, D.C. (May 15-19).

28. For more detailed discussions of SERDP budgets, see Butts, 1994. Also Dabelko, David D., and Geoffrey D. Dabelko. The International Environment and the U.S. Intelligence Community. *International Journal of Intelligence and Counter Intelligence* 6. Spring 1996: 21-41.

29. Deutch, John. The environment on the intelligence agenda. Speech at the World Affairs Council, Los Angeles, July 25, 1996. Deutch claimed that the intelligence community's environmental monitoring would enhance, not duplicate, the important work of civilian groups including the National Science Foundation, the National Oceanic and Atmospheric Administration, NASA, and academic institutions.

30. While potentially useful, such assistance could be problematic if the incriminating data were gathered by classified means and could not be readily declassified. The potential to link negative or embarrassing findings for one country to unrelated issues fits squarely in a competitive or conflictual framework of state behavior. One hypothetical scenario might include evidence of whaling or fishing treaty violations, gathered by classified means, being employed as a bargaining chip in unrelated trade negotiations on electronics import quotas.

Environmental dimensions of national security

Braden R. Allenby

For many readers, the concept of "environmental security," or the integration of environmental issues and national security considerations at a national policy level, may well be novel. It may even appear somewhat oxymoronic. It is, in fact, neither. Rather, it reflects recent history and trends, and the significant evolution of our knowledge of both fields. This is not to say that the concept is well understood—as the papers in this volume illustrate, that is a work in progress—nor, for that matter, that the concept is even universally accepted as valid. There are those in both the environmentalist and security communities who view such an integration with deep skepticism, even alarm.

More broadly, however, it can be argued that the debate about the validity and meaning of environmental security is a part of, and a reflection of, a number of basic trends that, taken together, mark this post-Cold War period as one of fundamental change. It may therefore be useful to explore this broader landscape within which the integration of previously disparate policy areas may be (is?) occurring, and at least alert the reader to some of the developments in the environmental and national security policy arenas. Hopefully, this discussion will provide a context within which the following papers and reference material can be more easily understood.

Post World War II acceleration of change

The great Austrian economist Joseph A. Schumpeter remarked upon the "gale of creative destruction," which characterizes capitalistic systems, a phrase that, taken broadly, aptly characterizes our time. The rate of change since the end of World War II along many critical dimensions has accelerated dramatically, and by all indications is set to continue. Consider only a few of the readily evident fundamental trends:

- the revolutionary nature of the globalizing economy, which not only changes regional and global class structures and distribution of income, but increasingly generates economic activity at a geographic scale beyond the nation-state;
- the end of the bipolar Cold War structure with its ironically comfortable definition of global geopolitics as conflict between capitalist and communist world ideologies;
- the "information revolution," which, among other things, sees modern electronic technologies and international information networks used as revolutionary weapons against the state (how quickly were the Chiapas rebels on the Internet? And did this change an internal police action to be resolved by military means into an international cause celeb that had to be addressed through negotiation instead?);
- the recognition that the scale of human economic activity is for the first time fundamentally affecting a number of basic global and regional physical, chemical and

biological systems, and the earliest beginnings of a scientific capability to model and understand these complex systems;
- the rise of the service economy, and a concomitant change in patterns of work and the social contracts that previously linked workers with firms;
- the devolution of power from the nation-state to local, regional and international institutions, to nongovernmental organizations (NGOs), and to transnational corporations and capital markets; and, partially as a result of these shifts; and
- the redefinition of virtually all social institutions, from the family to universities to private firms to the nation-state itself.

Granted that any effort to fully discuss these trends would require tomes, not a single introductory essay, they nevertheless suggest some basic unifying themes that are defining our time—and are useful in thinking about linkages between environmental issues and national security.

For example, it appears that we are moving towards a globalized economy and society that will not, however, be necessarily as homogeneous as those that characterized the Cold War period. Rather, both economy and society will become more complex in the technical sense: there will be more communities (perhaps, as a result of the Internet, of common interest rather than delineated through accident of geographical proximity), units, systems, interests, political and social entities, and technology clusters, at many different levels. Concomitantly, there will be many more interrelationships among them. Substantially more sophisticated policy structures will be required to understand and define—not to mention manage—the interests of nation-states in such an environment.

Additionally, it appears fairly clear that we as a species are moving towards an engineered world, in which our social and technological choices, whether made deliberately or not, determine the structure of the natural environment not just for humanity, but for all life as a whole. This trend is a product of the Industrial Revolution itself, but is becoming more widely apparent as science gains more ability to define the impact of human activity on fundamental natural systems. Indeed, in many ways we already live in an engineered world; the principal reason we don't recognize this is that the anthropogenic engineering of the globe has not been planned, but has simply happened as a result of the evolution of technology, increased population growth, and growing consumption levels. Use of the term "engineered world" does not imply, by the way, the usual over-simplistic technological optimism ("pump enough tropospheric ozone into the stratosphere and you will have solved the ozone depletion problem"). Rather, it implies what might become a new form of engineering—call it "earth systems engineering"—that recognizes the complex and unpredictable nature of the interactions among artifacts, culture, and the physical world; attempts to understand salient behaviors and interrelationships among these systems through, e.g., modeling; and is appropriately humble and experimental.

An analogous caution applies to policy development and deployment. Policy, including foreign policy, security policy, environmental policy, and science and technol-

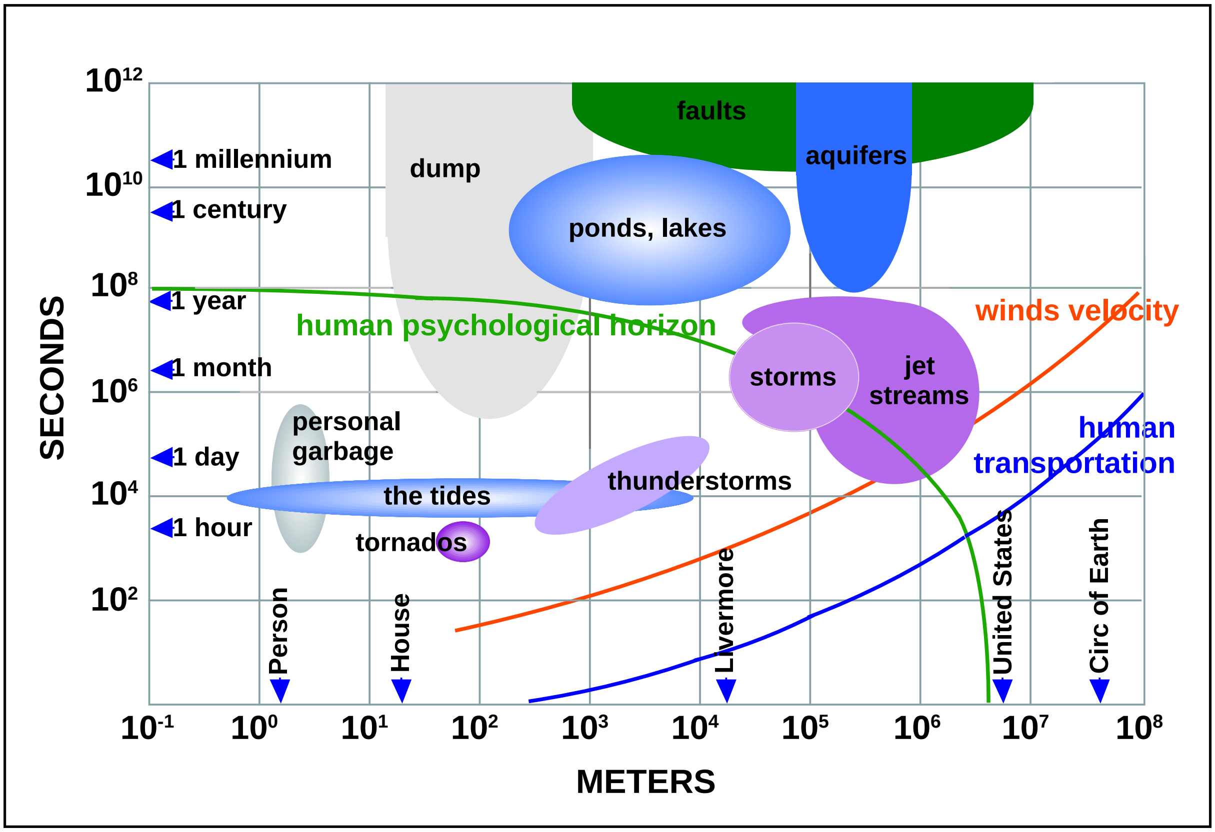

Figure 4-1. Human psychology and natural system scale.

ogy policy, generally functions in the short term and focuses on the interests of a specific geographic area. Limits arise either from political structure—such as terms of office, boundaries of nation-states—or, more fundamentally, from human psychological bounds. Most people don't think beyond a time horizon of a few years, and a geographic range of miles, or, at best, their region. Many of the natural and human systems with which national security and environmental policy in the broadest sense must deal, however, lie beyond these intuitive boundaries (see Figure 4-1). The evolution of successful nation-states, and, obviously, of many of the natural systems perturbed by human activity, occur over decades or even centuries. A critical question, therefore, must be how pragmatic policy systems can be developed that integrate gracefully and robustly over very disparate temporal and spatial scales.

In fact, the degree to which virtually every modern institution—from the family to major religions to academic and research institutions to the private firm to the nation-state—is changing is both unparalleled in modern times, and little recognized in the aggregate. While they are stable in the short term, in the long term at least some of these institutions will be quite different. Cultural systems (including the environmental and national security communities, for example) tend to find such change uncomfortable, and will accordingly try to minimize the reality of such all-encompassing change, if not actively resist it. Whether this is desirable is immaterial: it is a real phenomenon, and will be a difficult challenge for policy development.

Paradoxically, the opposite sin, that of apocalyptic projection, must be avoided as well, particularly as regards environmental perturbations. Although occasionally framed in such terms, it is highly unlikely that human activity at anywhere near current levels actually threatens "the world", "life", or even the existence of our species. This is not to minimize the irreversibility and critical nature of, for example, loss of biodiversity and habitat, which are clearly occurring even now. From a human perspective, however, what is threatened is the stability of global economic and social systems: should they collapse or shift dramatically, the impacts on human happiness, health, and mortality could be substantial, and recovery could take a long time.

Finally, it is important to recognize that the relationship among human population levels, patterns of economic behavior (including choice of technologies and consumption patterns), cultural systems and institutions (including private firms and nation-states), and supporting natural systems is a complex one. In particular, it is highly likely that there are a number of paths and conditions that could be sustained over some period of human generations, ranging from a Malthusian world where population levels are maintained by the mortality rate, to a world which is consciously designed to support a high level of biodiversity and a limited human population. Each might have a different mix of institutions and respective roles (nation-state, private firms, NGOs, international agreements and implementing bodies such as the World Trade Organization, etc.). This implies an interesting concept: that of choice at a social, rather than individual, level; "social free will." Given the religious, social, cultural, political, economic, and other constraints that exist, how free is a society, or global society taken as a whole, to choose alternate paths? What does it mean to exercise (presumably bounded) free will at the level of the social organization, be it private firm or nation-state, rather than at the individual level? And how can individuals impact these "organizational choices" in a predictable manner? More pragmatically, if one wishes to discuss the integration of global long-term environmental issues and the quintessential characteristic of the nation-state —that is, national security—can one avoid for long an assumption about a desirable path and end state?

The evolution of environment from overhead to strategic

The integration of environmental considerations into the national security apparatus of any nation, including the United States, can be seen as one example of a broader transition of environmental issues from "overhead" to "strategic" for consumers, producers, and society itself (Allenby, in press). Used in this sense, "overhead" issues are those that are ancillary to primary functions, much as environmental issues are treated under traditional command-and-control, end-of-pipe regulatory structures. "Strategic" issues, on the other hand, are those which are viewed as integral to the primary activity (Table 4-1). For a firm, for example, building a water treatment plant at a manufacturing facility is overhead; changing product designs and business plans in response to European ecolabeling initiatives is strategic.

Table 4-1. Transition of environment from overhead to strategic accountability.

Time Focus	Past	Present; emphasis on past	Present/future looking
Endpoints	Reduction of immediate human risk	Reduction of immediate human risk	Sustainability, including: • global climate change • loss of biodiversity • degradation of water, soil, and atmospheric resources • ozone depletion
Geographic/ Temporal Scale	Local immediate	Point source; immediate	• Regional and global systems at all time scales
Principal Activity	Remediation	Compliance	• Industrial ecology • Design for environment • Environmentally conscious design and manufacture
Focus of Activity	Waste substances sites	Emitted substances; emphasis on end-of-pipe controls	• Products and services over life cycle • Industrial and consumer behavior in actual economy • Resultant environmental impacts
Relationship of Environment to Economic Activity	Overhead	Overhead	Strategic

On a social level, the transition of environmental issues from overhead to strategic inevitably implies conflict with existing legal and policy structures. Such structures—including, for example, those dealing with consumer protection, government procurement, antitrust, trade, or, in this case, national security—have generally been created over the years without any explicit consideration of their environmental implications. In effect, the environmental externalities associated with existing legal and policy regimes have been both unrecognized, and ignored. This is natural enough, given the treatment of such issues as overhead until recently.

The increasing focus on complex environmental perturbations such as stratospheric ozone depletion and global climate change, and concomitant development of new, integrative fields such as industrial ecology, however, has demonstrated that the overhead approach is inadequate to achieve fundamental progress in responding to environmental challenges. The broadening awareness of the fundamental linkages among cultural, technological, economic and environmental systems (Allenby and Richards 1994; Socolow et al. 1994; Graedel and Allenby 1995; IEEE 1995) has, at the same time, made the need to integrate environmental dimensions into existing legal systems more apparent. The environmental externalities imposed by these structures as they are currently constituted are seen as no longer acceptable. Several examples may clarify this transition.

That the integration of environment with other policy systems is not necessarily an easy process can be seen by the conflicts and problems that have arisen as the world's trade system, embodied in entities such as the World Trade Organization (WTO) and the North American Free Trade Agreement (NAFTA) zone, struggles to combine free trade and environmental protection. In many cases such as this, not just regulations, statutes and treaties, but cultural models and worldviews are involved, and the synthesis of legal requirements is accordingly complicated by the need for acculturation of, and mutual acceptance by, previously disparate groups. Thus, for example, a trade community which had heretofore dealt with environmental requirements, if they dealt with them at all, as protectionist trade barriers, is having to come to terms with environmentalists. The latter, in turn, tend to view the global economy, and thus trade, as somewhat suspect in itself, but an ideal tool to impose extraterritorial environmental requirements. Using trade in this way is, however, strongly constrained by international law, which, being based on the foundation of the absolute sovereignty of the nation-state, significantly limits the ability to impose one country's environmental values on another through trade (Hartwell and Bergkamp 1994). Moreover, both groups are also beginning to understand that free trade, economic development, and environmental protection are all valid policy goals, but it may not be possible to optimize all at the same time (Repetto 1993). How to evaluate the inevitable tradeoffs has not yet been determined.

Even after two years of intense discussion, for example, the WTO's Committee on Trade and Environment (CTE), set up as a forum to discuss such issues, remained deadlocked as of 1997 on a number of critical issues. These included establishing the compatibility of WTO trade rules with measures taken under multilateral environmental agreements (known as MEAs); who settles disputes when MEAs and WTO rules conflict (both structures are based on treaty and international agreements and thus of equal legal stature); how to resolve disputes alleging that ecolabelling schemes constitute nontariff trade barriers; and how to treat environmental taxes and charges in light of WTO trade rules. Disputes not only pit developed against developing countries (the latter concerned with environmental standards that might discriminate against products from their countries, and thus act as protectionist trade barriers). There are also disagreements among OECD countries, with the Europeans in particular claiming that American trade representatives show little enthusiasm for environmental considerations. Thus, although the adjustment for both the environmental and the trade communities is coming along, it remains difficult and is by no means complete yet (Raul and Hagen 1993).

Another example may be drawn from industry. The quasi-governmental ecolabel, the Blue Angel, is awarded to products within designated categories that meet certain requirements derived from environmental policies. In many German markets, the ecolabel is highly desirable, and can confer market advantage. In the case of the Blue Angel for personal computers, two of the more rigorous requirements were that the product be designed to be modular, and that the manufacturer have a takeback program in effect. Modular design means that each functional assembly—the modem, the disk drive, etc.—must be removable by the consumer, so that the system can be upgraded without throwing away the whole unit. The environmental purpose is to reduce the waste stream from obsolete personal computers. This requirement is, however, an extremely difficult design challenge, especially where the technology is evolving so rapidly. It means, among other things, that the design team must segregate function within different units, ensure that the interfaces among units are robust to technological evolution, and do so while still being competitive with products that don't bother to get the Blue Angel. Among the obvious implications of this requirement is that the manufacturer will sell less units, which has obvious implications for product management and business planning.

Product takeback, which means that the manufacturer must take its products back when the consumer is through with them, and refurbish them, recycle the components, or recycle the constituent materials, makes the manufacturer responsible for the product at its end of life. The purpose of this requirement is to internalize to the manufacturer the end-of-life costs of its product, which will, over time, result in more environmentally efficient designs, and reduce the waste generated by trashed personal computers. Takeback programs have, however, significant business implications. It means that a manufacturer that may be low cost in manufacturing machines but cannot develop an efficient reverse logistics system to get its products back—or cannot design a machine that is easily refurbished, upgraded, or recycled—may well not be competitive. It also means that a manufacturer must learn to think of its product in terms of managing its lifecycle, rather than simply manufacturing it and forgetting about it. In the long term, post-consumer product takeback is a step towards the so-called "functionality economy," where customers buy function rather than product, and manufacturers remain responsible for the product through its entire lifecycle. In one sense, this is not as radical as it sounds; many leasing programs resemble this system already. In another sense, however, it turns manufacturing firms into service firms, and dramatically changes the very nature of the firm.

With both modular design and product takeback, it is obvious that one is dealing with strategic challenges for the firm, not simply overhead. Environmental considerations cannot simply be treated by putting another scrubber on the plant, but must be integrated into virtually every facet of the firm's operations: business planning, product design, strategic planning, financial management, research and development. Indeed, the electronics industry has developed a new competency, called "Design for Environment," or DFE, to reflect the need to integrate relevant environment constraints and objectives into its design and manufacturing operations.

The relatively arcane world of military specifications and military standards (MILSPEC and MILSTD in the United States) for products, and the interrelationship of this legal structure with stratospheric ozone depletion, provides a third relevant example. The military in most countries is a large purchaser of goods and complex weapons systems, and the manufacturing, design, and maintenance of these products is usually governed by complex sets of contracting, procurement, and operating requirements, including MILSPEC and MILSTD. These requirements, of course, have been drawn up over the years to ensure appropriate performance of products and systems under the extreme conditions of military use, and have virtually never had any environmental inputs. They form a powerful and complex cultural and legal system.

Depletion of stratospheric ozone, on the other hand, is a classic and elegant example of unanticipated impact of human economic activity on fundamental natural systems. In this case, anthropogenic gases, primarily the chlorofluorocarbons (CFCs), which are quite stable, were found to be migrating to the upper atmosphere where, subject to energetic sunlight, they released their chlorine, which, in turn, catalyzed the destruction of stratospheric ozone. Stratospheric ozone in appropriate concentrations in the stratosphere is important because it blocks highly energetic sunlight from hitting the earth's surface, where it can cause significant damage to living things. Once this relationship was understood, the international community accordingly crafted a response, the Montreal Protocol, which aimed to eliminate production and use of CFCs.

So far, so good. The MILSPEC/MILSTD regulatory structure protects the performance characteristics of military systems, and the Montreal Protocol responds to a serious environmental threat. But CFCs are not just an emission from certain industrial processes that can be controlled by a scrubber (thus treating environment as overhead). Rather, they were at the time a critical material in electronics and metal piecepart manufacturing - in other words, they were an integral part of the manufacturing complex. They were strategic to manufacturing, not overhead. And this created conflict between the two previously disparate regulatory structures of environment and MILSPEC/MILSTD.

Thus, it is perhaps not surprising that, when the American electronics industry began to phase out ozone depleting substances pursuant to the Montreal Protocol, the single biggest barrier to prompt phaseout was not technical, not economic, not scientific—but MILSPEC and MILSTD. In fact, because of cross referencing in government, industrial, and commercial documents, and use of the rigorously tested MILSPECs and MILSTDs as industry standards around the world, it has been estimated that half of all CFC-113 use worldwide for the manufacture of electronics circuit boards was driven by U. S. MILSPEC and MILSTD (Morehouse 1995). Weapons systems like the C-130 aircraft, for example, had literally thousands of maintenance applications where the only acceptable process involved CFCs.

Overcoming this barrier did not imply ignoring the procurement system and the attendant specifications, or reducing the technical rigor of performance requirements. After all, the policy rationale for this particular system—robust performance under adverse conditions—was both strong and continuing. Rather, the process involved the integration of environmental and performance requirements into a new generation of MILSPEC and MILSTD, which met the goals of both environmental and military procurement policy. This case study is, in effect, not just one of environment being recognized as strategic to the interests of society, but one of environmental security as well.

And this, in general, is the pattern throughout social and legal structures as environment is increasingly recognized as legitimately strategic for society: initial conflict, followed by negotiation and identification of the valid policy principles of both regimes, followed by creation of a new integrative structure. It is Hegelian in a way: the thesis of the existing legal structure is challenged by the antithesis of the newly recognized environmental requirements, which then combine in a synthesis which (in an ideal world) combines the appropriate elements of both. Thus, the concept of environmental security can be seen as one example, but not a unique example, of a dynamic occurring in many areas.

Changing dimensions of national security

With this as background, it is now useful to turn to that function that, for many nation-states, is the most critical: national security. The constellation of issues that support, or threaten, the fabric of a state and its territorial integrity are, virtually as a matter of definition, those of most concern. Two principal and comfortable assumptions that have supported the traditional view of such issues are 1) that the nation-state is relatively absolute, and, 2) since the beginning of the Cold War, that the conflict between capitalism and communism in various forms defined global geopolitics. These assumptions, at least in their absolute form, are becoming less valid. The termination of the Cold War, and, concomitantly, a global geopolitical structure based on rival nuclear superpowers with clearly opposed ideologies, has resulted in a more complex security environment. Regional and local historical, political, cultural, environmental, and economic pressures that were repressed during the preceding decades are now emerging, and, in conjunction with the loss of state control of weapons of mass destruction, proving to be significant sources of potential security threats and destabilization of existing states.

The degree to which these changes are viewed as real or lasting varies; it would be inaccurate to imply consensus at this point. As in any rapidly changing environment, there are significant differences in individual and institutional perception, and the importance given to various potential trends and developments. Some believe little change is required; some, like Jessica Mathews (1977) (and Brown, infra) believe that global civil society is being redefined:

> The end of the Cold War has brought no mere adjustment among states but a novel redistribution of power among states, markets, and civil society. National governments are not simply losing autonomy in a globalizing economy. They are sharing powers—including political, social and security roles at the core of sovereignty—with businesses, with international organizations, and with a multitude of citizens groups . . . . The steady concentration of power in the hands of states that began in 1648 with the Peace of Westphalia is over, at least for a while. . . .
>
> Increasingly, resources and threat that matter, including money, information, pollution, and popular culture, circulate and shape lives and economies with little regard for political boundaries. International standards of conduct are gradually beginning to override claims of national or regional singularity. Even the most powerful states find the marketplace and international public opinion compelling them more often to follow a particular course.
>
> The state's central task of assuring security is the least affected, but still

> not exempt. War will not disappear . . . [n]ontraditional threats, however, are rising—terrorism, organized crime, drug trafficking, ethnic conflict, and the combination of rapid population growth, environmental decline, and poverty that breeds economic stagnation, political instability, and, sometimes, state collapse. . . These trends have fed a growing sense that individuals' security may not in fact reliably derive from their nation's security.

Under these circumstances, the Cold War operating definition of national security based on a bipolar world and primarily military confrontation, is thought by many to be too limited. Accordingly, a number of suggestions for expansion of the concept, focusing primarily on the concepts of "economic security" and "environmental security", have accordingly been made (Mathews 1989; Renner 1989; Executive Office of the President 1996). (This publication focuses on environmental security issues: economic security, although related, is conceptually and analytically a separable topic.) And it seems true that, if environmental issues and perturbations are strategic to a society, one would expect them to become a prominent dimension of national policy (Mathews 1989; Homer-Dixon et al. 1993; Homer-Dixon 1994a).

American policy has indeed begun to evolve in response to these recent challenges, in part by recognizing the need to manage a new set of issues, generally captured in the concept of "environmental threats" as part of a broader national security mission. Thus, in 1996 the Administration noted that (Executive Office of the President):

> The decisions we make today regarding military force structures typically influence our ability to respond to threats 20 to 30 years in the future. Similarly, our current decisions regarding the environment and natural resources will affect the magnitude of their security risks over at least a comparable period of time. . . . Even when making the most generous allowances for advances in science and technology, one cannot help but conclude that population growth and environmental pressures will feed into immense social unrest and make the world substantially more vulnerable to serious international frictions.

In a subsequent speech at Stanford University on April 9, 1996, Secretary of State Warren Christopher explicitly recognized the need to include additional dimensions in American foreign policy:

> . . . our Administration has recognized from the beginning that our ability to advance our global interests is inextricably linked to how we manage the Earth's natural resources. That is why we are determined to put environmental issues where they belong: in the mainstream of American foreign policy.
>
> . . . The environment has a profound impact on our national interests in two ways: First, environmental forces transcend borders and oceans to threaten directly the health, prosperity and jobs of American citizens.

> Second, addressing natural resource issues is frequently critical to achieving political and economic stability, and to pursuing our strategic goals around the world.
>
> In carrying out America's foreign policy, we will of course use our diplomacy backed by strong military forces to meet traditional and continuing threats to our security, as well as to meet new threats such as terrorism, weapons proliferation, drug trafficking and international crime. But we must also contend with the vast new danger posed to our national interests by damage to the environment and resulting global and regional instability. . . . A foreign policy that failed to address such [environmental] problems would be ignoring the needs of the American people.

Thus, it is fair to conclude that, at least for some leaders in the Clinton administration, the need for an "environmental security" policy is increasingly recognized and accepted. It is less clear that the dimensions of this requirement, and the means by which it can be institutionalized in existing policy structures, have been adequately worked out. After all, there are many resource scarcities and environmental perturbations around the world, most of which will impact the United States only minimally. In 1995, for example, the National Science and Technology Council identified:

> . . . a broad class of global threats evident in the post-Cold War world affect our nation's security. . . . In the modern world . . . environmental degradation can have global consequences that threaten the populations of all nations. Great human suffering due to natural disasters or to other environmental economic or social and political factors may lead not only to large numbers of refugees crossing international borders but also to instability that increases the likelihood of ethnic and regional civil conflict. . . . global threats such as climate change, ozone depletion, and ocean pollution may take years or even decades to become apparent and build toward crisis. Yet each of these poses challenges to the health and long-term well-being of both U.S. citizens and people throughout the world.

Incidents and issues in each of these areas may raise foreign policy or security concerns, but clearly in most cases will not. Moreover, the resources to respond to challenges in these areas are limited, and their allocation must be prioritized to ensure that national security is not jeopardized, and that the most benefit is obtained for their use. This raises a critical analytical point.

It is very important to differentiate between the perspectives of a global view, where one views human security or, more broadly, biological security as a whole, and a nation-state view, which focuses on the interest of the nation-state rather than global systems (see Figure 4-2). Even at the level of the nation-state, it is necessary at a minimum to differentiate between national security issues and *foreign policy* issues, between those situations that implicate American foreign policy initiatives in some way, and the more limited subset that proximately involve national security. For example, disease in

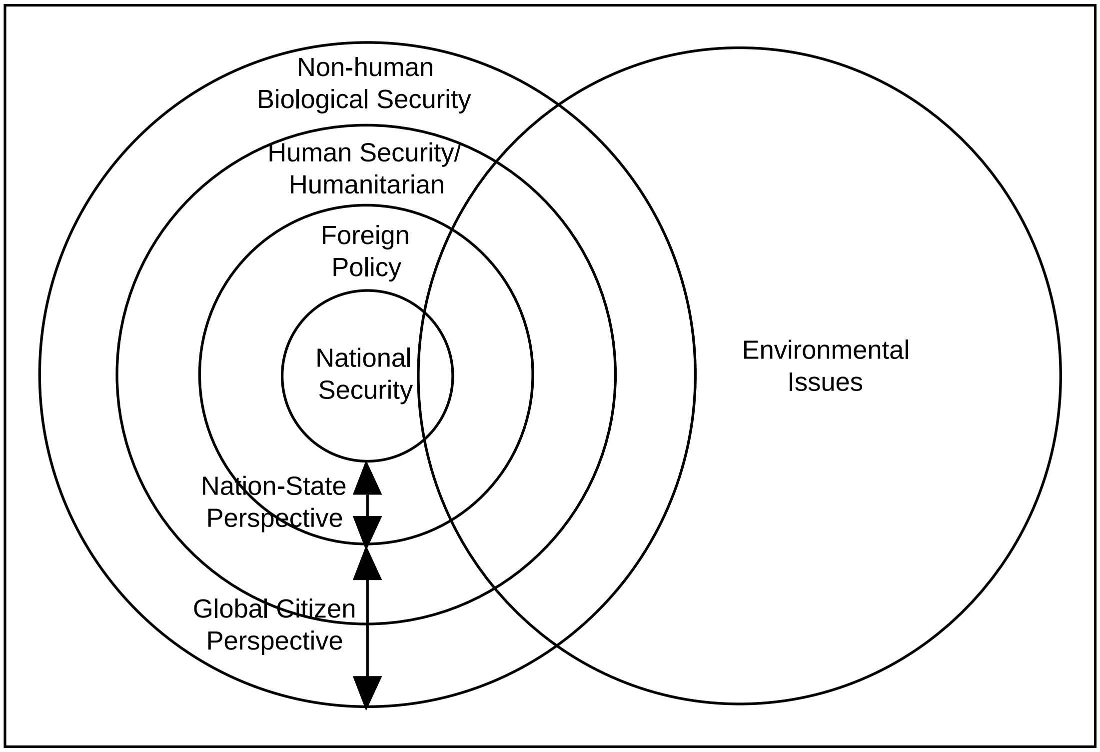

Figure 4-2. Intersection of environmental and security issues.

an African state that limits the ability of the state to develop economically by reducing the ability of the population to work and imposing substantial health care costs, is an obvious humanitarian concern, and may generate appropriate relief efforts. If resources are available, for example, the international NGO community, which tends to take the global rather than the nation-state view, usually attempts to respond to such conditions. Depending on circumstances, such a condition may be a foreign policy concern of the United States. It will probably not, however, be viewed as a national security issue.

On the other hand, destabilization of Chinese agricultural production as a result of changes in precipitation patterns, which leads to augmented internal and external population migrations, raises not only humanitarian issues appropriately dealt with through foreign policy initiatives, but is quite clearly a potential national security issue as well.

It is important to realize that designating a set of issues as national "security" issues in no way implies the necessity of an adversarial approach, although this was usually the case during the Cold War. Rather, it increasingly identifies areas where collaborative confidence building measures are increasingly being used. It is generally in the interests of all states involved in a situation where destabilization or conflict might occur to work together to avoid such an outcome if possible.

In this light, it is probably fair to say that the initial attempts in the United States to expand the Cold War concept of national security to include other dimensions, such as environment, have, perhaps, been too inclusive. Many considerations and issues that realistically do not have significant potential to substantially and adversely impact the security of the United States or its citizens have been included, and, conversely, little consideration has been given to excluding issues that, even if they may have such impacts, are not appropriately considered as a part of national security (for reasons of institutional capabilities and culture, for example). This has perhaps unnecessarily impeded acceptance of the fundamental legitimacy of the extended concept, particularly in the security community, which tends to favor traditional, military definitions (Fleishman 1995). Moreover, a failure to specify issues and concerns can, as the trade example indicates, lead communities to talk past each other, and become fixated on perceptual, rather than real, differences. Accordingly, it would greatly facilitate the successful implementation of an enhanced national security mission if it can be rigorously defined in such a way that it can both be operationalized, and understood as legitimate by the national security community as a whole.

The nub of the problem is, of course, that there is no commonly accepted definition of national security. Webster's New World Dictionary defines "security" in relevant part as "protection or defense against attack, interference, espionage, etc. (funds for national security)," which, although seemingly specific, allows enormous leeway: "interference" is a subjective term, and the "etc." allows in what the rest of the definition might preclude. Nor are the U.S. government's attempts at definition necessarily more rigorous. The Administration, for example, has defined three goals in its *national security strategy* (Executive Office of the President 1996, 11-12, italics added):

> **- Enhancing Our Security**. Taking account of the realities of the new international era with its array of new threats, a military capability appropriately sized and postured to meet the diverse needs of our strategy, including the ability, in concert with regional allies, to win two nearly simultaneous major regional conflicts. We will continue to pursue a combination of diplomatic, economic, and defense efforts, including arms control agreements, to reduce the danger of nuclear, chemical, biological, and conventional conflict and to promote stability.
>
> **- Promoting Prosperity at Home**. A vigorous and integrated economic policy designed to put our own economic house in order, work toward free and open markets abroad and promote sustainable development.
>
> **- Promoting Democracy**. A framework of democratic enlargement that increases our security by protecting, consolidating and enlarging the community of free-market democracies. Our efforts focus on strengthening democratic processes in key emerging democratic states....

This definition, carried through in other Administration documents, encompasses a broad range of potential threats and issues, including but not limited to economic development, trade, and, included in the concept of sustainable development, virtually all regional or global environmental perturbations (e.g., National Science and Technology Council 1995). Many in the traditional national security community (sub silentio for the most part) view these definitions as far too broad, even as they may accept them as legitimate foreign policy issues, at least on a case-by-case basis.

Perhaps the most measured definition which also captures the ambiguity of the term is provided by Jack Goldstone (1996):

> There is only one meaningful definition of national security, and it is not inherently military, environmental, or anything else. Variations of that definition guided us throughout the cold war, and long before. That definition goes something like this: A "national security" issue is any trend or event that (1) threatens the very survival of the nation; and/or (2) threatens to drastically reduce the welfare of the nation in a fashion that requires a centrally coordinated national mobilization of resources to mitigate or reverse. While this seems common sense, it is clear from this definition that not any threat or diminution of welfare constitutes a national security threat; what does constitute such a threat is a matter of perception, judgment, and degree—and in a democracy, a legitimate subject for national debate. . . . What has begun is an empirical assessment, within an existing and long-reasonable definition, of whether environmental trends, because of their threat to our survival or welfare, must be given attention according to this definition.

The question of whether, or how, to integrate environmental and security considerations can therefore be seen as at least partially empirical, requiring both intellectual structure, and data gathering and assessment, to answer. This implies a necessary role for science and technology, a theme that many of the papers in this volume implicitly support. Developing such focused knowledge through appropriate research and development activities fulfills the critical need, given limited resources, to create a filter mechanism that can provide at least a conceptual framework to support issue identification and prioritization (see Allenby in this volume). Common sense, for example, dictates the policy principle that, all things equal, investment in relevant science and technology (S&T) should primarily be directed at creating a targeted S&T base that defines and supports specific critical elements of an enhanced national security mission, rather than being scattered across all potential foreign policy issues, or even potential environmental security issues. This would appear to be a fruitful approach, at least initially: rather than immediately jumping to the level of ideological confrontation, it reduces unnecessary conflict by first asking what issues can be resolved through empirical assessment and greater scientific and technological knowledge, and what issues properly remain in the domain of ideology and politics.

The role of institutional cultures and capabilities

The clash in underlying cultures between environmentalists and members of the national security community is apparent (but can be over-emphasized). Environmental NGOs often tend to be open, nonhierarchical, and liberal in ideology. They also tend to have the global, rather than the nation-state, perspective, as well as some aversion to technology and traditional military activities.

Conversely, the national security community in most countries is conservative, insular, heavily focused on military threats and challenges, secretive, and powerful; it also tends to focus on short-term, obvious problems. In this, it simply reflects the nature of its mission. Culturally, such security communities are among the least likely to embrace environmental considerations, and, when they do so, to do so only in a mission-oriented context (see, for example, Department of Defense 1995). More specifically, some in the security community believe that environmentalists and environmental scientists, facing cuts in their research funding, are urging "environmental security" as a means to obtain funding from security research programs, which in many countries remain relatively robust.

In this inherently somewhat adversarial positioning, the security community resembles the trade community, and the initial dialogs with environmentalists have some of the same cultural tension on both sides. Yet, as in trade, these institutional differences need not prevent collaboration on issues of joint interest. Indeed, as this volume itself demonstrates, to some degree a broader integration is already beginning in countries such as the United States, although the dialog appears to be tentative, somewhat contentious, and relatively unsophisticated at this point.

Another often overlooked point bears emphasis: Even if an environmental perturbation may pose a significant threat to a nation, it may still not be a national security issue if it falls outside the competency and culture of the national security community and its component institutions.

For example, assume arguendo that anthropogenic global climate change is both real and can be shown to have such substantial negative impacts on the United States that it clearly meets usual operational definitions of national security threats. An argument can still be made that it is not a "national security" issue, at least in toto. This is because the scientific and technological research and development capabilities to understand and respond to the phenomenon would reside broadly throughout the civilian research community, not within the traditional security organizations (the Department of Defense and the CIA, for example). Moreover, the scientific process most likely to result in rapid development and deployment of relevant knowledge would be the traditional one of open dialog and peer review, not the more secretive one that tends to characterize science and technology within the security community. A National Science Foundation, not a Department of Defense, would be institutionally and culturally better positioned to support such a program. This does not mean, of course, that the security establishment would not have some specific concerns (e.g., would any critical allies or areas of the world likely be destabilized by sea level rise), only that the issue, taken as a whole, is best not viewed as a "national security" issue.

Another example is stratospheric ozone depletion resulting from anthropogenic release of chlorofluorocarbons (CFCs) and other ozone depleting substances. In the absence of mitigation (which fortunately seems to be occurring), estimates of potential impacts include upwards of a million new cancer cases annually in the United States alone, with concomitant substantial mortality and economic loses. Many other significant human health and biological (agricultural) impacts are also possible. Such occurrences would obviously constitute a significant threat to the citizens of the United States, yet virtually no one has argued that ozone depletion should be handled as a "national security" issue. Indeed, trying to do so might well have derailed the broad research and technology deployment effort with which industries in many different sectors responded to the challenge of eliminating CFCs from their operations. At the same time, as the discussion of MILSPEC and MILSTD illustrates, there are dimensions of the ozone depletion issue that had significant operational impacts on military operations and weapon systems, and had to be addressed by, and within, the military and security communities.

Conclusion

At the conceptual level, therefore, we may initially pose a three-part test to determine whether an environmental issue or perturbation should be considered as an "environmental security" issue:

1. Are the potential impacts of the environmental perturbation in question substantial enough to be considered a national security threat?

2. Are the links between the environmental threat and the relevant impact(s) relatively certain and proximate? For example, one might argue that a collapse of the Mexican tuna fishery might encourage increased migration of unemployed tuna fishermen to the United States, which might cause political problems in California, which might generate social unrest in that state. The framework of the suggested problem is so speculative, however, and the links between the potential cause and the effect of concern are so vague and uncertain, that it is hard to argue that the state of the Mexican tuna fishery is an issue of national security for the United States.

3. Even if the environmental threat is substantial, certain and proximate, is the national security apparatus institutionally and culturally the most capable of mounting an effective response? And, if so, to all or only to selected dimensions of the threat?

It is difficult to consider these questions without recognizing the uncertainty implicit in the concept of "environmental security" at this nascent stage. Equally, however, it is apparent from the papers in this publication that the costs of failing to respond appropriately to the fundamental suite of changes now affecting both the environmental and national security areas, albeit in different ways, could be large. Accordingly, a reasoned discussion of the issues, with minimal unnecessary conflict among the different communities that must be involved, would appear to be highly desirable. It is the intent of this volume to support such an outcome.

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Learning from the arms control experience

Ronald F. Lehman II

Arms control and disarmament policy became an integral part of America's national defense strategy during the Cold War. The implementation of that policy brought with it into the security arena a number of environmental issues. In some instances, addressing environmental concerns was a major goal of our arms control agenda, as in the treaty banning environmental modification as a method of warfare (U.S. Arms Control and Disarmament Agency 1996). In other cases, environmental problems presented challenges to the achievement of other goals, as in the obstacles created by clean air standards to the rapid elimination of ballistic missiles required by new treaties.

The environmental consequences of conflict were also a matter of debate within the arms control community: for example, the fear that a "nuclear winter" could follow a global war, the controversy over use of defoliants in counter-insurgency operations, and the uncertainty about regional consequences of Saddam Hussein's burning of the Kuwaiti oil fields during the Gulf War. Environmental degradation was increasingly seen also as a cause of conflict or a hindrance to peace. Concerns that environmental threats might undermine negotiations led to considerable parallelism in the Multilateral Middle East Peace Process as the Arms Control and Regional Security (ACRS) working group found itself following closely developments in the working groups dealing with water, refugees, and economics.

As we consider suggestions that our notions of international security be broadened or enhanced to include a greater centrality for environmental issues, insights can be gained from recent arms control experience. In part, that experience places before us case studies of the national security establishment coming to grips with environmental questions. Perhaps of even greater value is the recognition that the arms control policy process, with themes, institutions, and individuals mirroring and even overlapping those involved in the environmental policy process, has debated many of the same issues now central to the question of what is "environmental security." Thus, one can gain some insight into the role environmental issues play in national security by looking at the arms control experience. In the process, thinking about what is meant by "environmental security" may be clarified.

Admittedly, the methodology of looking at arms control to determine how it became a new national security discipline involving, but somehow different from, diplomacy, military strategy, or international law is to generalize from a part to the whole. Certainly, the arms control and disarmament agenda is but one of many national and international security considerations. Yet, the same is also true of the environmental security perspective. Thus the analogy may be even stronger. In a sense, in both cases the germ of the whole is contained in the parts. Just as the history of arms control is filled with the history of broader political, social, economic, and military affairs, so the history of environmental security will reflect these as well.

The analogy of arms control to environmental security is not a perfect one. Arms control, ultimately recognized as a specialty, of necessity involves the very essence of national security no matter how defined. Arms control deals with military weapons, forces, and operations, the traditional "stuff" of national security. Arms control tries to help address relatively directly the causes of war and the consequences of war. Arms control theory incorporates and is incorporated into the theories and strategies of national security. The same cannot now be said of most environmental threats except in the very broadest sense of "security." Furthermore, much of the contemporary discussion of environmental security involves expanding our current concept of national security to incorporate many or all environmental threats rather than filtering out those threats that do not meet today's definition of national security.

The multiple personalities of "environmental security"

The idea of "environmental security" is not new, but in recent years it seems to have taken on a greater sense of urgency.

> Within the next decade, what has been called "the environment" holds promise of emerging as the most troublesome problem in the field of international relations. Complex enough in a physical sense, the issue grows even more intricate on the political plane through its close association with health and survival. Until the recent past, strategic considerations of a nation have been based on its national interests, and although this kind of thinking may be not completely out of date, it is now definitely not adequate. This is because the national security of a country is not only threatened by other nations with hostile intentions but also by the increasingly serious problem of environment (Sien-chong 1977).

The above statement is particularly interesting because it was made in 1977 and was published in a NATO journal. It was neither the first such declaration nor the last. Neither was it definitive. The author, Niu Sien-chong, did not advocate a field or discipline called "environmental security," but the author did highlight a number of ways in which environmental concerns impinged upon international security, ranging from threats common to all the inhabitants of the Earth to the impact of antipollution regulations on the operations of naval vessels on the high seas and in coastal waters. The author also highlighted the importance of environmental and health considerations in bringing about the ban on nuclear explosive tests in the atmosphere. More significantly, however, Niu Sien-chong highlighted to the defense community environmental threats to national security that were largely independent of nation-state conflict.

Interest in an "environmental security" perspective has continued to grow, but no consensus has yet emerged on how central environmental issues are to traditional national security policy. Nor has a consensus been achieved that the concept of national security should be broadened to include at its core the security issues we normally associate with prosperity and well-being beyond basic freedom from military violence and coercion. Some analysts have gravitated toward the view that environmental security involves environmental threats to the stability or survival of regimes and peoples. Indeed, for a number of these analysts the real test of the relevance of environmental issues to national security is the degree to which conflict is involved or the deployment of military forces becomes essential.

The current debate over a definition of environmental security reflects more than different ideas about how best to organize our thinking and clarify our language. It also involves differing ideologies, budget priorities, and institutional special interests. The debate even reflects alternative views of national sovereignty and the future of the nation–state in an increasingly transnational and subnational world. Indeed, the battle over the scope of environmental security parallels in many ways past and present disputes that arose within the field of international security during the Cold War over the proper role of arms control.

As we look at recent arms control activities to inform what we might say "environmental security" is, a number of questions can usefully be kept in mind:

- How relevant, how significant, and how immediate are environmental challenges to traditional national security as we have known it, and vice versa?
- Has an "environmental security" perspective, practice, or even discipline emerged in policy or technology that involves a broader concept of national security?
- What is the role of the defense community from both a broad and a narrow perspective?
- What does this mean for defense science and technology?

Environmental issues in the arms control arena

One does not need to detail the history of environmental issues in arms control to measure their impact. It is considerable. In some examples, environmental concerns about specific military activities are raised. In other examples, environmental goals themselves are promoted or come into conflict with other objectives. It is not uncommon for a number of environmental objectives to come into conflict with each other as well. In the broadest sense, all arms control can be said to be about the environment. Still, it is seldom that environmental substance is as central and explicit as was the case with the Environmental Modification Convention (ENMOD).

Environmental Modification Convention (ENMOD)

A common strategy in arms control is to identify potential threats early in their formation so that they can be managed more easily. Once competitive pressures accelerate actions and reactions, policy factions become polarized and special interests become dependent upon programs. At that point, often only a defining event or crisis can inspire change. Banning something no one has is easier than banning something everyone wants. The Environmental Modification Convention (ENMOD) is an example of acting before a capability is in hand (USACDA 1966, 153-159).

In the late 1960s and early 1970s, a number of experiments in the modification of weather for benign purposes were conducted. In particular, science was put to work examining whether the uncertain art of "rainmaking" by seeding clouds could be made more effective. The hope was that water could be directed to more productive uses or even that storms could be mitigated. As scientists debated the merits of peaceful weather modification, they also began to express concerns about the possibility that weather modification might be used for military purposes in ways harmful to the environment.

During the Vietnam War, congressional hearings were held on experiments conducted in Southeast Asia. Although a number of experts had described possibilities for altering climate or manipulating natural forces such as earthquakes and tidal waves, such technologies did not seem near at hand. Nevertheless, momentum for international action grew, in part influenced by the much more immediate and intense debate over the ecological consequences of the use of herbicides in Vietnam and the possibility that the Red River dikes near Hanoi might be bombed.

The resulting "Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques" was opened for signature in Geneva on May 18, 1977. Two and a half years later, the United States ratified the ENMOD treaty. The essence of the convention is contained in Article I, Section 1: "Each State Party to this Convention undertakes not to engage in military or any other hostile use of environmental modification techniques having widespread, long-lasting or severe effects as the means of destruction, damage or injury to any other State Party."

The convention fell short of a ban on weather modification for military purposes or peaceful purposes and did not itself ban the use of technologies or techniques that have a temporary or limited effect on the environment. "Environmental modification techniques" were defined in Article II as "any techniques for changing—through the deliberate manipulation of natural processes—the dynamics, composition or structure of the Earth, including its biota, lithosphere, hydrosphere and atmosphere, or of outer space."

It was left to the "Understanding Relating to Article II," which is not incorporated into the treaty, but is part of the negotiating record, to provide more detail:

> It is the understanding of the Committee that the following examples are illustrative of phenomena that could be caused by the use of environmental modification techniques as defined in Article II of the Convention: earthquakes, tsunamis; an upset in the ecological balance of a region; changes in weather patterns (clouds, precipitation, cyclones of various types and tornadic storms); changes in climate patterns; changes in ocean currents; changes in the state of the ozone layer; and changes in the state of the ionosphere.

The understanding goes on to explain that these examples are not exhaustive. The ban is based upon a principle not a list of prohibited activities. Nevertheless, the ban is subject to certain thresholds most notably "destruction, damage, or injury" that is "widespread, long-lasting, or severe." These later terms are explained in the "Understanding Relating to Article I":

> It is the understanding of the Committee that, for the purposes of this Convention, the terms "widespread", "long-lasting" and "severe" shall be interpreted as follows:
>
> > (a) "widespread": encompassing an area on the scale of several hundred square kilometers;

> (b) “long-lasting”: lasting for a period of months, or approximately a season;
> (c) “severe”: involving serious or significant disruption or harm to human life, natural and economic resources or other assets.

The prohibitions in the ENMOD Treaty are among the most general in any arms control agreement. The lack of specificity reflected in part the very preliminary scientific understanding of techniques or technologies that might be involved. To deal with this problem, the ENMOD convention provides for a “Consultative Committee of Experts” and for the possibility of review conferences every five years.

Another reason why the provisions of the ENMOD are so generic becomes clear when one considers the policy and political circumstances of the times. Concern about protecting or providing a clean, safe, productive environment, independent of its national security aspects, had been growing. The ENMOD Treaty itself, in its preamble, offers highlights:

> *Recognizing* that scientific and technical advances may open new possibilities with respect to modification of the environment,
>
> *Recalling* the Declaration of the United Nations Conference on the Human Environment adopted at Stockholm on 16 June 1972.
>
> *Realizing* that the use of environmental modification techniques for peaceful purposes could improve the interrelationship of man and nature and contribute to the preservation and improvement of the environment for the benefit of present and future generations . . .

On its face, the ENMOD Treaty anticipates technologies for peaceful, desirable modifications of the environment and Article III makes clear that “this Convention shall not hinder the use of environmental modification for peaceful purposes. . .” and that parties “have the right to participate, in the fullest possible exchange of scientific and technological information on the use of environmental modification techniques for peaceful purposes.” As in the case of the nuclear Nonproliferation Treaty (NPT), the Chemical Weapons Convention (CWC), and some other arms control agreements, ENMOD promotes the distribution of technology for peaceful purposes even at the risk that the spread of that technology may proliferate destructive capabilities which are prohibited by the same treaties.

In the case of the ENMOD Treaty, however, the real motivation for concluding the convention that was finally agreed upon was more to further the goal of protecting the environment from major harm than in preventing new capabilities of immediate military consequence. Further language contained in Article III reinforces this point: “States parties in a position to do so shall contribute, alone or together with other States or international organizations, to international economic and scientific cooperation in the preservation, improvement, and peaceful utilization of the environment, with due consideration for the needs of the developing areas of the world.”

In form, ENMOD contains a structure similar to that of some other arms control treaties. In substance, however, it lacks much of the specificity of contemporary arms control treaties. Its subsequent implementation reinforces this view also.

Faced with the prospect that the Gulf War coalition would attempt to expel his forces from Kuwait, Iraqi leader Saddam Hussein threatened to burn the Kuwaiti oil fields. A number of scientists produced calculations suggesting that the environmental consequences would be devastating over wide areas of southwest Asia. Many groups and individuals, environmentalists and others, opposed to going beyond sanctions, added this fear of environmental devastation to their argumentation. For an American government contemplating air and ground attacks against Iraq and Iraqi forces, Saddam Hussein was presenting an environmental threat (and an economic one as well) as a deterrent. Public opinion was increasingly concerned. In this case, and in future cases, the national security policy of the United States requires the science and technology to determine how credible such environmental threats are. The alternative could be self-deterrence on the one hand or possibly a horrible environmental mistake on the other hand.

The United States was not deterred by Saddam Hussein's environmental hostage-taking, just as it was not deterred by Iraq's chemical and biological weapons or its nuclear weapons program. Still, the threat was real. Iraqi forces did ignite massive fires in the Kuwaiti oil fields, and they also pumped huge volumes of oil into the Persian Gulf. These may have been acts of retaliation or retribution as threatened, but they also seemed aimed at complicating coalition military operations. Interestingly, the international legal community was divided over whether these actions constituted violations of the Environmental Modification Convention. The U.S. government, after reviewing the case, decided at that time not to charge Iraq with such a violation.

Extensive environmental harm as a result of warfare is not in all cases banned by ENMOD, and some environmental harm can result from a range of military and combat operations. A number of national and international efforts, within arms control and outside it, have sought to deal with some of these other environmental risks. Public opinion has been particularly sensitive to environmental dangers with public health connotations. The same public opinion which largely ignored the use of chemical weapons by Iran and Iraq, an arms control compliance question, has become increasingly focused on science's inability to present explanations for the so-called "Gulf War Syndrome." In attempting to understand an uncertain pattern of symptoms, a number of physicians have suggested the possibility that a number of medical maladies suffered by veterans of that war are the result of environmental factors. These factors include the possible effects of chemical or biological agents manufactured by Iraq, side-effects of American vaccines and antidotes, air pollution from the burning oil fields, and fuels and industrial chemicals used in military operations. The American public is more aware now because its own citizens are suffering, but the insidious nature of lingering environmental poisoning that strikes close to home galvanizes public opinion to examine national security in ways that other arms control challenges and even war in foreign lands do not.

Nuclear explosive testing

If the ENMOD Treaty is the clearest and largest example of arms control attempting to address environmental concerns, the history of negotiations of nuclear test bans provides earlier examples of an environmental imperative in arms control. From the beginning of the nuclear age, concern about the health consequences of atmospheric detonation of nuclear weapons proved more powerful in motivating public political action than did arcane arguments about crisis stability or complex theories of an arms race. In many ways, the peace movements of the 1950s were the prototypes of many environmental groups today. Certainly, the “Ban the Bomb” and “Better Red than Dead” slogans of that era were concerned with the potential devastation that a nuclear war could bring, and in that sense were environmental security themes as well as national security issues.

More immediately compelling, however, was the measurable harm done to people exposed to radioactivity and to habitats near test sites. Indeed, the fact that fallout from a distant, single source could be measured around the globe contributed to international action and transnational political mobilization in opposition to testing. Despite a national security rationale for continued nuclear weapons testing, President Eisenhower felt it proper to announce a nuclear testing moratorium in 1958, which, after an extensive Soviet nuclear test series, lasted for three years. The massive atmospheric tests by the Soviet Union that ended that moratorium in 1961 served to re-energize interest in arms control and disarmament and led to the completion of the Limited or Partial Test Ban Treaty (LTBT) in 1963.

The environmental protection function of the LTBT is highlighted in the preamble in which the parties “desiring to put an end to the contamination of man’s environment by radioactive substances,” agreed to the treaty that bans testing: (a) in the atmosphere; beyond its limits including outer space: or under water, including territorial waters or high seas; or (b) in any other environment if such explosion causes radioactive debris to be present outside the territorial limits of the State under whose jurisdiction or control such explosion is conducted. . . (USACDA 1996, 29).

The ban on testing in the atmosphere reduced interest in further limits on nuclear testing, in part because underground testing offered less environmental impact and permitted national security concerns to be addressed. Venting from underground testing did, however, prompt support for further limitations and in 1974, the Threshold Test Ban Treaty (TTBT) was signed limiting underground nuclear weapons tests to 150 kilotons (USACDA 1996, 133–137). Two years later, the Peaceful Nuclear Explosions Treaty (PNET) was signed limiting the use of nuclear explosions for nonmilitary purposes also to 150 kilotons (USACDA 1996, 133–141).

The public debate over proposals to use nuclear explosives for canal building, diverting rivers, mining, and the like prompted great opposition from environmentalists. Nevertheless, neither the TTBT nor the PNET was particularly popular with these groups. Both were seen by most such activists as small steps that served to legitimize continued nuclear testing. Lack of enthusiasm for the TTBT and the PNET by some parts of the environmental community and concern about verification among many in the national security community resulted in no definitive action on these treaties until after a new Verification Protocol had been negotiated between the United States and the Soviet Union. The treaties only entered into force in December 1990.

In the absence of atmospheric testing, environmental arguments for a Comprehensive Test Ban (CTB) carried less weight in most of the policy community than countervailing national security considerations. In 1996, long after the Cold War was declared over, a CTB Treaty was finally concluded. During public discussion of the CTB, environmental concerns about underground testing of even very small explosions were featured, but the main arguments presented by negotiators for the CTB involved arms control and nonproliferation. Many significant groups acting in support of the CTB, however, are leaders in environmental activism.

Antarctic Treaty, Seabed Treaty, Outer Space Treaty, etc.

The LTBT, with its obvious focus on the environment, was not the first of the modern arms control agreements nor was it the first to deal with the environment. Those accolades go to the Antarctic Treaty, signed in December 1959 (USACDA 1996, 11-17). The Antarctic Treaty demilitarizes that continent and provides the institutional basis for peaceful cooperation. Although some individual states continue to protect claims to mineral resources and national control there, the spirit of the treaty has been to keep the southern polar region as pristine as possible. This has been aided by the emphasis given to international scientific cooperation in Antarctica, which is encouraged by the treaty. Science in Antarctica frequently has focused on global as well as local environment studies. The effort to protect the environment in areas not yet spoiled by the burdens of civilization and the destructiveness of war has continued. In 1967, the Outer Space Treaty was concluded, and in 1971, the Seabed Treaty was opened for signature (USACDA 1996, 35-41, 80-85).

A parallel focus on keeping regions unspoiled has developed within nation states. Frequently, military activities are permitted in and around built up areas but are prohibited in areas less impacted by people such as deserts, mountains, and forests. This has added another example of the impact of environmental issues on national security as the location of strategic radars, missile fields, and the like have been subjected to more careful environmental review. Indeed, the environmental impact statement (EIS) and its related process now covers a wide range of national security activities including defense conversion. Follow-on use of closed military facilities is now also subject to environmental review because many such installations have large unpopulated areas where protected flora and fauna reside. The arms control community copied this review concept in the legislative requirement under which, for many years, the U.S. Arms Control and Disarmament Agency (ACDA) was required to issue an arms control impact statement (ACIS) on proposed weapons systems and even some early technology.

The nuclear nonproliferation regime

Environmental concerns about nuclear technology have played heavily in national security debates. Environmental consequences of nuclear war or from the plants and laboratories that support nuclear weapons, however, are not the only issues. Perhaps more environmental activism has been focused on the civilian use of nuclear technology, especially nuclear power. Again, to the degree that economic prosperity means "economic security," the international arms control community has sought to accommodate the peaceful uses of nuclear technology while trying to control the spread of nuclear weapons and other military use of nuclear technology. In some cases, however, the distinction between peaceful and nonpeaceful is blurred.

The accident at Chernobyl generated greater caution about nuclear power plants, but it also re-energized fear about the dangers posed by military nuclear forces. That the great arms control agreements between the United States and the Soviet Union—the Intermediate-Range Nuclear Forces Treaty (INF) and the Strategic Arms Reduction Treaty (START)—followed relatively soon after the Chernobyl disaster is not surprising.

The centerpiece of the nuclear control regime is the Nuclear Nonproliferation Treaty (NPT) concluded July 1, 1968 (USACDA 1996, 65-79). Of the 193 nation states typically considered candidates to join treaties, 183 are already parties and Taiwan also is considered bound by its provisions. Among countries with advanced nuclear technology, only Brazil, India, Pakistan, and Israel are not parties. Brazil is, however, a party to a similar, earlier regime, the Latin American Nuclear-Free Zone Treaty of 1967, also known as the Treaty of Tlatelolco (USACDA 1996, 45-64). Under Article IV of the NPT, nuclear cooperation for peaceful purposes is encouraged among parties, but under Article VI, all nations are committed to "General and Complete Disarmament (GCD)" with the five recognized nuclear weapons states required to work toward "an early end to the nuclear arms race" and nuclear disarmament. All other parties are prohibited from having nuclear weapons or programs to acquire them.

In support of the NPT, the International Atomic Energy Agency (IAEA) was created. The IAEA inspects fissile material to ensure that it has not been diverted for military purposes, but it also promotes scientific cooperation, including in the environmental sciences. Many of the verification technologies used have parallels in environmental sampling. Much of the model for cooperation and confrontation on environmental issues among international bodies, governments, industry, nongovernmental organizations, and publics developed in the context of the NPT regime. The regime has been strengthened by additional agreements such as the Nuclear Material Physical Protection Convention (USACDA 1996, 218–227); a Fissile Material Cut Off treaty is being negotiated under which no fissile material would be produced by any country unless under international safeguards.

In short, the NPT is the keystone of a nuclear technology management regime. It also has important disarmament implications in Article VI especially for the five nuclear weapons parties and further important environmental implications in that another 178 countries covering much of the globe have agreed to forgo nuclear weapons and weapons complexes immediately, thus mitigating some environmental concerns. This continues the process of the Treaty of Tlatelolco of limiting nuclear weapons activity on a broader geographical basis. A number of additional nuclear weapons free zones have been established, including in the South Pacific, Africa, and Southeast Asia. Although these treaties seek to keep nuclear weapons out of their zones, signatories have had to compromise continuously with the nuclear weapons states on the issues of transits of ships or aircraft with nuclear weapons on board and the transit or port calls of nuclear powered ships and submarines.

Given that the United States lost two nuclear submarines at sea early in its program and that more recent Russian nuclear submarine sinkings and accidents have caused alarm in Scandinavia and Japan, environmental concerns over the deployment of nuclear technology at sea has been long-standing. Major steps have been taken by both Russia and the United States to remove tactical nuclear weapons from the high seas. These steps have been followed by increased bilateral and multilateral efforts to deal with problems such as the Russian dumping of radioactive power assemblies and components at sea. Because the major nuclear forces of Britain, France, and the United States are at sea, however, environmental opposition to all deployments of nuclear weapons at sea or to naval nuclear propulsion could have vital national security consequences. Russia and China may also wish to maintain nuclear submarines at sea. Also, one of the reasons that Brazil has given for not joining the NPT is that it does not wish to compromise its options to acquire naval nuclear propulsion technology for military submarines.

Chemical and biological weapons

The Geneva Protocol of 1925 prohibited "the use in war of asphyxiating, poisonous other gases, and of bacteriological methods of warfare" (USACDA 1996, 5–10). It was not proclaimed by the United States until 1975, in part over a dispute as to whether it limited herbicides. The Executive Branch determined that it did not, but agreed to consult with the Senate before changing existing restrictive use. The Geneva Protocol banned use, but not research, development, testing, production, and stockpiling. In 1972, the Biological Weapons Convention (BWC) instituted such a ban (USACDA 1996, 95–104). No provisions were made for verification of the BWC. This was justified on two grounds. First, deterrence could be maintained by chemical or nuclear weapons. Second, verification would be necessary for a ban on chemical weapons and from that process measures might be identified that would build confidence that the compliance with the BWC was taking place.

Biological warfare was not new, and the historical abhorrence to it reminds us again that public health fears are among the most powerful in dealing with either national security or environmental matters. The revolution in biotechnology and health sciences, to include manipulating genetic material, has set off alarms in both the defense and environmental communities and adds an additional dimension to the notion of environmental security. At the same time, both concerns run into fears that intrusive inspection might compromise intellectual property rights and proprietary information as well as personal privacy. The emerging battle over strengthening the BWC will undoubtedly illustrate the difficulty in balancing the broader definitions of security.

The Chemical Weapons Convention (CWC), which contains the most detailed and intrusive inspection regime ever negotiated, was finally concluded in January 1993 (USACDA 1993, 247–267). Many modern chemical weapons grew out of medical studies conducted at the turn of the century on industrial diseases, or what some today call environmental health. Not surprisingly, a major issue in negotiating the CWC was the question of how to verify the convention without unduly disrupting the chemical industry. As with the BWC, proprietary information, intellectual property, and personal privacy were all issues. Concern exists that foreign governments, potential proliferators or terrorists, or commercial competitors may gain dangerous access to sensitive information. During the negotiation of the CWC, concerns arose that domestic environmental watchdog groups or regulatory agencies would focus on data exchanges and inspections for evidence of pollution or unsafe practices.

Developing countries were particularly sensitive to the possibility that the CWC would expose them to embarrassment over abuse of the environment, but developed counties also expressed concerns that bodies like our Environmental Protection Agency

(EPA) would use the CW arms control process to tip them off to problems. Such concerns were magnified by the use of some of the same verification sensor and sampling technologies that are used for monitoring compliance with environmental regulations. The similarity of the challenges had, in the United States, resulted in a memorandum of understanding between the EPA and ACDA. The administrative and procedural regulatory aspects of arms control can look very much like the environmental regulatory process. Indeed, during recent discussion of CWC ratification in the U.S. Senate, critics pointed to reporting requirements for small business not central to the chemical industry as a potentially unwarranted regulatory burden, which, in their view, would be worse than the American regulatory bureaucracy alone because it would be directed by an international organization based in the Netherlands.

Other similarities between the environmental regulatory process and arms control emerge in the CW arms control regime. The United States and the Soviet Union negotiated a separate Bilateral CW Destruction Agreement designed to strengthen confidence in compliance and to develop monitoring experience. That agreement, not yet in force, provided that CW destruction must take place in a “safe and environmentally sound” manner. Consideration of what was “environmentally sound” led to the enhancement of a grassroots environmental movement in Russia not unlike that which has been a major player in the development of the U.S. CW destruction program. This process has reinforced the development of democracy in Russia, but, as in the United States, “NIMBY—Not in My Back Yard” is often the watchword. The current major U.S. CW destruction site is on Johnston Island, isolated in the South Pacific Ocean far from populated areas. When the United States proposed to move its CW stocks in Germany to Johnston Island to be destroyed, many environmental groups on the Pacific Rim were opposed. Similar groups in Europe, however, were more supportive.

Interestingly, much of the controversy over the environmental implications of CW destruction has to do with the basic environmental debate over the safety of incineration of toxics. The similarities to broader contamination issues is also strong. In Wyoming in 1989, the United States and the Soviet Union negotiated a Bilateral CW Data Exchange Agreement. When Russia reported on its stocks, the amount was far smaller than was known to have been produced. When queried, the Soviet Union, which had no significant CW destruction facilities, indicated that it had disposed of huge amounts. The bad news is that they might have been lying. The worse news could well be that they were telling the truth. Huge amounts of chemical weapons may have been dumped in ways that would be totally unacceptable today by environmental standards. The Soviet proposal that chemical weapons be destroyed with underground nuclear weapons detonations illustrates a very different view of environmental security.

Regulating nuclear arms

Another regulatory aspect of the arms control process that parallels the environmental policy experience is known as the “gray area” problem. When the growth of strategic nuclear weapons began to be limited by the Strategic Arms Limitations Treaties (SALT I in 1972 and SALT II in 1979), the importance of missiles of less than intercontinental range increased. The completion of the Strategic Arms Reduction Treaty (START I) was made by the Soviet Union contingent upon the Intermediate-Range Nuclear

Forces Treaty (INF) in 1987. Both INF and the START Treaties illustrate the problems of substitution and circumvention that have plagued the environmental regulatory process. The nuclear force negotiations also offer examples of environmental issues impinging upon national security such as air quality standards limiting the rate at which missiles could be destroyed.

The more important lessons in the search for the meaning of “environmental security,” however, may come from some broader considerations. INF and START were greatly influenced by theories of behavior and balance first derived from economic models and later transplanted to the interactions of technologies. Environmentalism today is struggling with concepts of risk–benefit analysis and is still trying to model global, regional, and local environmental equilibrium and “sustainable development.”

At the same time, the nuclear arms negotiations took place in the depths of the Cold War. Political, economic, strategic, and ideological factors weighed heavily, just as they often do in disputes over environmental policy. Under these circumstances, the arms control process found that the many scientists who were involved in the nuclear arms control process brought with them different ways of examining and characterizing problems. Often, they helped resolve the questions of incommensurates. More often, they offered alternative language, which was less politically charged. This, of course, did not erase the fundamental differences, but scientific language helped make possible politically acceptable compromises that were deemed militarily acceptable.

Similarly, nuclear arms control did not cause either side to forget that the other was a potential adversary, but the destructive potential of nuclear weapons made it possible to focus on them as a common threat requiring cooperation. When the debate over “nuclear winter” emerged, the overlap between environmental threats and military threats was made clear, even if the scientific community found itself divided over the quality of its atmospheric, oceans, and related environmental modeling. The national security community, already convinced of the destructiveness of all out nuclear war, was not greatly influence by the findings, but the political climate was influenced by the debate. In a sense, the debate over global warming raises many similar political, social, and economic considerations.

One also sees the North-South split, found so often in arms control negotiations, playing an even greater role in environmental negotiations. Developing countries anxious for economic growth frequently resent being denied the right to make the same mistakes that the developed countries have already made, whether it is air pollution or an arms race. All countries speak of threats to the environment as a common enemy, but environmental diplomacy like arms control negotiations is filled with maneuvering for advantage. Everyone understands that all is not a “zero-sum” game, and most understand that zero-sum thinking can be harmful to all. Unfortunately, relative gain can be as important in the minds of policymakers as absolute gains, particularly when there is a national security dimension, and environmental issues such as the tension between protecting the environment and promoting economic growth can raise national security concerns. In summary, an examination of arms control illuminates linkages between national security and the environment. It also illustrates similar concepts and behavior in analogous matters which are only distantly related. North-South disputes over the migration of older, pollution causing technologies to poor countries parallels disputes over the migration of older weapons to developing nations.

Defense economics and nonweapons of mass destruction

Principal objectives of arms control are to reduce the economic burdens of defense and to encourage the economic and political conditions which discourage conflict. The end of the Cold War has accelerated interest in achieving these objectives. The Treaty on Conventional Forces in Europe (CFE) has resulted in the destruction of vast arsenals of tanks, artillery, and aircraft. Disposing of this equipment in ways that are affordable, verifiable, and protective of the environment also has not been easy. At one point, the Soviet Union, which had once suggested the use of nuclear weapons to destroy chemical weapons, proposed that military equipment be dumped in the ocean to form reefs able to sustain fish and other marine life. This strained effort to bring defense and economics together with the environment reads like the debate today over whether some examples of "recycling" and "industrial ecology" have been stretched beyond a solid business foundation.

The end of the Cold War has exposed important environmental challenges such as the massive cleanup required at military installations that have been shut down. These cleanup problems, in turn, complicate the conversion of defense installations and industries to peaceful uses, which in turn creates domestic and international tensions. Defense conversion programs and cooperative threat reduction programs such as provided for by the Nunn-Lugar legislation of necessity must take on these environmental challenges.

Another aspect of arms control that might be considered part of an environmental security perspective is dealt with in the Convention on Conventional Weapons (CCW). Current efforts seek to block the spread of land mines, particularly those that are scattered and abandoned only to take the lives and limbs of innocent people long after conflict has ended. This can be considered an environmental issue in that the threat is analogous to the spread of toxic waste. The harm to populations is steady and cumulative and denies access to important land resources.

Arms control and environmental security: similarities and differences

The arms control analog to environmental security goes beyond the examples discussed above. The arms control process also illustrates how the national security bureaucracy organized to meet environmental challenges. It is not uncommon to hear environmental activists complain that the foreign policy community buries within its much broader agenda disputes such as compliance with international law on drift nets and other undesirable fishing techniques. The complaint is one familiar to the arms control community which itself complains, for example, that our economic ties with China water down our nonproliferation agenda. Diplomats respond, of course, that just the opposite may be true; namely, that political engagement strengthens the entire U.S. agenda.

Environmental policy, like arms control, constitutes an encroachment on core "national security" turf. Bringing more players to the table complicates decisions and implementation. Bringing more perspectives to the table makes the calculation of risks and benefits more difficult. Bringing more institutions and programs to the table can increase costs overall, reduce the funding of existing activities, and introduce other inefficiencies. Indeed, as arms control became a larger part of national security, defense programs sought to be labeled “arms control.” When “nonproliferation”, “and then “counterproliferation” received emphasis, many of the same activities sought the new labels. The same will be true as “environmental security” moves into the spotlight. Arms control often sought to be labeled a “defense” program in order to gain access to defense dollars. Defense programs sought to be labeled “arms control” in order to gain public support. The same behavior is likely if “environmental security” catches on. Environmentalist will be seeking defense dollars, and national security programs will be seeking support from environmentalists to protect their current funding.

These similarities in bureaucratic behavior should not be dismissed as nothing but greed. Underneath the self interest are important implications for thinking about broader definitions of “security.” The environment, the economy, energy, resources, biology/ecology, and national security are all related, but some relationships are close and others are not. Grand histories of civilizations, and archeological evidence of prehistoric societies, suggest that changes in weather, water, forests, and soil have contributed to the rise and fall of civilizations and peoples. If resource depletion or climate change created the migrations and invasions out of Central Europe that altered significantly the histories of Europe, the Mediterranean, India, and the Middle East, at one very high level, that is “environmental security.” If lead poisoning of an elite privileged enough to have lead utensils and pipes brought about the collapse of the Roman Empire, (Gilfillan 1970, 55-60) that might also be called “environmental security.” If nations deploy diplomacy and military forces abroad to protect sources of raw materials and their transit routes, is that a form of “environmental security” (Mahan 1890)? If national security is a precondition for economic development that, in turn, has generated some of the most “green” attitudes within the wealthiest countries, then should this also be called “environmental security”? (See, for example, *Raw Materials & Foreign Policy*)[1] This approach, however, illustrates the danger of defining either national security or environmental security too broadly. They lose their essence. Environmental security, like arms control, overlaps, interacts, complements, and supplements national security, but the wider we spread the concept, the more shallow our concept may become.

The arms control experience also reflects many of the same political dynamics that influence environmental decisions. Some citizens find compromising among competing goods easy. Others demand to know why any good should be sacrificed. Navigating this realm is not easy. Both arms control and protecting the environment are good, but each carries a price. In this regard, a marketplace of ideas that also brought broader science and technology to the table proved useful in promoting worthy compromises in the highly polarized arms control arena, and it has also been useful in dealing with environmental disputes.

An examination of the emergence of arms control as a multi-disciplinary security discipline including, but different from diplomacy, law, and strategy may prove useful to those who see environmental security more as an academic field or professional discipline rather than as a category, a grouping of issues, or a perspective. Arms control issues clearly required a collection of knowledge and skills that went beyond any single traditional approach to national security. At the same time, drawing upon economic theory, behavioral theory, and scientific analysis, arms control was able to put forth a “general theory” or at least a number of models that unified the arms control perspective tightly. One saw debates over whether arms control should be defined narrowly as negotiated agreements, or broadly as including nonproliferation, defense conversion, and even elements of peacekeeping and human rights. That the value of arms control skills seemed to be less on the periphery of the definition does not distract from the existence of a solid core to the definition.

Environmental security may not yet have found the solid core to anchor its broader application. If one attempts to include the wide range of environmental issues one seeks within national security tightly enumerated, relevance suffers. The alternative of broadening the definition of national security to make environmental security fit more naturally runs the opposite risk; namely, of undermining the value of the contributions those activities related to protecting the environment can make to national security.

The discussion above, both the examples and the analogies, hopefully have illuminated useful similarities and differences in thinking about arms control and environmental security as national security fields. The parallelism can be misleading, however. Important differences exist between the two concepts. Arms control has much more proximity to the causes and consequences of conflict. It deals more emphatically with military weapons, forces, and operations. Arms control has been incorporated into the national security process because it can be seen to have rather immediate consequences for the survival of a nation-state or regime. Because so many environmental security concerns are chronic, they lack the sense of immediacy that motivates national security action. Arms control offers somewhat greater clarity in its national security theory, and more of its policy strategies are seen as linked to present rather than future generations overall. In short, arms control has been more successful at quantifying its “security” impact on states and societies. Arms control, whatever our dissatisfaction with its analytical rigor, has been able to identify a systemic “security” equilibrium or path attractive to national security policymakers.

Science and technology in support of environmental security

Science and technology helped create our arms control and environmental challenges. It may also help in addressing them. This analysis of arms control and environmental security has stressed that not all problems are technical, but it has also suggested that science and technology can help even with nontechnical issues. Scientists and engineers may be no better at policy than some policymakers are at understanding technology, but the scientific style of thinking can help illuminate, and sometimes quantify nontechnical issues. It can help us understand systemic relationships and trade-offs, and thus clarify policy questions.

At the tactical level, the scientific style can provide new language with less bias or bile to market compromise, and it can introduce different ways to measure success, which may facilitate the process without undermining the achievement of goals. By broadening the circle of players and, perhaps also the issues, science can expand the possible, viable compromises. Of course, the major contribution of science and engineering is to provide technological solutions to those problems that are amenable to technical solutions. Not surprisingly, many of the very technologies that are associated with the conduct of the Cold War are now used to help put the Cold War behind us.

Conclusions

The arms control experience provides considerable insight into the ongoing debates over what environmental security is and what we should do about it. Many of the issues, institutions, decision-making processes, and even individual actors overlap. The differences are as important as the similarities, but important lessons can be learned, particularly about the contributions of science and technology.

Environmentalism, like interest in arms control and disarmament, predates the industrial revolution, but both owe their contemporary centrality to the downsides of technological progress. Environmentalism and arms control both map onto the incredible numerical, economic, and scientific growth of mankind over the past century. Each illustrates the power of an overarching, positive theme, yet each works through human institutions, which evolve slowly. Each must deal with the impact of rapid change on societies, but human nature itself seems relatively constant. And each bears heavily on the future of our security.

Arms control has become an established discipline in the field of national and international security. The "environmental security" perspective, however, has not found such a niche. As with economic security, energy security, and resource security, the idea of environmental security seems to bubble up each time an environmental issue intrudes upon the boundaries of national security, whether it be the cleanup of former military bases, the prospects of conflict over water, or the rise and fall of civilizations due to climate change or ecological degradation. That there are important security implications of environmental issues is widely accepted; that a discipline of environmental science and policy rests near the center of the study of military conflict is much less clear.

Everything is related to everything, but some things are more related than others. Arms control has been defined in the broadest of terms to include disarmament, nonproliferation, confidence- and security-building, verification, enforcement, transparency, defense conversion, unilateral restraint, and elements of peacekeeping, as well as negotiated constraints. It has also been defined narrowly to mean arms limitations that are negotiated but that are less than disarmament. Whether defined broadly or narrowly, however, arms control became a discipline because diverse issues were pulled together by common logic, common actors, and a sense of urgency, and it became a national security discipline because its subject matter *inter alia* are the implements of war. Environmental security seems to be moving in the direction of a discipline, but does not yet seem to have arrived. In part, reluctance to define the word security in a way that is distant from conflict and the use of force continues to inhibit the development of a discipline called environmental *security.*

Whether one defines security broadly or narrowly, environmental issues are at play in foreign and defense policy and in military operations. If these issues should prove too disparate to form a broader discipline or too lacking in immediacy to constitute a more focused discipline associated with the balance of military forces and their deployments, the concept of environmental security will still continue as a perspective that informs the national security community. Thus, a fresh look at how arms control evolved as a discipline (under the influence of economic theorists, technologists, and statesmen, etc.) and at how as a discipline it has dealt with what one might call environmental security issues (nuclear testing in the atmosphere, the Environmental Modification Convention, defense conversion, the destruction of chemical and other weapons, Open Skies, the land mine cleanup crisis, etc.) may be helpful in clarifying our thinking about the environment and security.

Environmental security, like the arms control perspective, builds upon a broader view of security that encompasses well-being and prosperity. Yet, both also have important implications for more specific, essentially military elements of national and international security. Each requires a multidisciplinary approach weaving together fields as diverse as economics, biology, electronics, law, diplomacy, and strategy. Both require global awareness, but they are also particularly sensitive to national differences. Both are steeped in theories of cooperative behavior; still, both present arenas for continued competition. Both present attractive visions of global public goods, but both involve tough policy and economic decisions that can translate nonpartisan goals into highly polarized political debate wherein the trade-off of one public good for another inevitably subjects any compromise to the critique of having given up too much for too little.

Because both environmental security and arms control deal with the unintended consequences of the advance of technology, both have of necessity invited the scientific community to join the debate over policy problems and solutions. At the heart of both fields are questions about technology; questions that must be dealt with in the midst of the significant political, social, and economic differences such as the East–West, North–South, and "have–have not" splits. In such a divisive climate, the distinction between "political science" and "political" science can blur. Progress has required that scientists be brought more deeply into the political process, and laymen must understand science and technology more than ever before to secure their futures. This certainly proved true in the emergence of arms control as a national security discipline.

Science, however, brought more to arms control than just its scientists. It brought new tools, new processes, new language, and new standards. Similar opportunities exist in support of environmental security concerns. National technical means of verification (NTM) bring to mind enhanced environmental sampling and modeling. The cooperative development of such systems constitutes a transparency and confidence-building process. Scientific jargon cannot make real differences disappear, but environmental security can benefit, as arms control did, from precise terminology keyed to an analytical process. This, in turn, leads to functional measures of merit. A more science-based approach to environmental security may reformulate questions in ways that can permit answers that most people find compelling.

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International law[1]

Edith Brown Weiss

Three hundred and fifty years ago, the Peace of Westphalia established a new international legal order based on sovereign, independent, territorially defined states, each striving to maintain political independence and territorial integrity. The system was hierarchic, since states controlled everything under them, and based on equality among sovereign states. It reflected a laissez faire philosophy, in which all states were equally free to pursue their own interests, whatever their underlying economic or political differences. As the system of sovereign states found in Europe spread across the globe, so did the international legal system based on it.

The Permanent Court of International Justice articulated the classical view in the famous 1927 S. S. Lotus Case between France and Turkey: "international law governs relations between independent States. The rules of law binding upon States therefore emanate from their own free will as expressed in conventions or by usages generally accepted as expressing principles of law and established in order to regulate the relations between these coexisting independent communities or with a view to the achievement of common aims."

The classical view implicitly adopts the Realist School that states are monolithic bodies and does not treat entities within states, transnational entities, or individuals as important. It relies on binding legal instruments to provide solutions to clearly defined problems and assumes that states comply with their international legal obligations. There is a sharp line between international and domestic law and between public and private international law.

But the international system has been rapidly changing and with it the international legal system. This has important implications for the role of international law in addressing issues of environmental security.

Factors causing change

Two changes in the international system have profound implications for international law and environmental security: the simultaneous push toward integration and fragmentation, and the rise of thousands of organizations and millions of individuals as relevant actors.

As we approach the next century, our world is becoming both more integrated and more fragmented. Evidence of global integration abounds: regional trading units; the European Union; global communication networks such as the worldwide web; and international regimes covering issues ranging from arms control and national security, to trade and banking, to human rights and environmental protection. The spread of financial markets, penetration of industries across borders, information revolution and other rapid technological advances, global environmental problems, and other interdependencies compel greater integration. Global cooperation will be needed to address many problems effectively.

At the same time, nationalism, ethnicity, and the need for personal affiliations and satisfaction push toward fragmentation and decentralization. Less than 10% of the more than 185 states today are homogeneous ethnically. Only about 50% of the states have one ethnic group that accounts for three-fourths of the population (Nye 1992). Scholars write about the rise of tribalism and the revealed need for community bonds. Increasingly states are relinquishing elements of sovereignty to transnational networks of nonstate actors, but the sense of community (with intense loyalty and identification) that binds the citizens of the state is not being extended to the networks.

A new divide is fragmenting the international system: between states and their nonstate transnational elites, on the one hand, and the ethnic, nationalistic, orthodox religious, dispossessed, and alienated communities on the other.

The emerging international system is structurally nonhierarchic. It consists of networks of states, nonstate actors, and individuals (Jacobson 1979). While states continue as principal actors, their freedom to make decisions unilaterally is increasingly restricted, and nonstate actors are performing increasingly complex tasks. States are still the only actors that can tax, conscript, and raise armies, but the importance of these functions has declined relative to the newly important issues, such as environmental security.

Within the community of sovereign states, by contrast, hierarchy has emerged. At the beginning of this century, there were only 34 states; in 1945 when the United Nations was formed there were 51. Today, there are more than 185 states. While all states are sovereign, they are in fact not equal in their relations with each other, even though the doctrine of sovereign and equal states still prevails in international law. Weighted voting provisions in international organizations, differential legal obligations depending upon economic ability and principles such as "common but differentiated responsibility"—all reflect a more hierarchical community. Thus, within the nonhierarchic international system, there is new hierarchy among sovereign states.

There are many actors other than states today in the international system. The 1995/96 Yearbook of International Organizations records 5668 intergovernmental organizations and 36,054 nongovernmental organizations, for a total of 41,722 international organizations. There are other relevant actors also: multinational corporations, ethnic groups, subnational governmental units, and ad hoc transnational associations. These new transnational elites are interested in particular outcomes and may have extensive resources at their disposal. Indeed the budgets for certain nongovernmental organizations exceed the budgets of members of the European Union, and certainly the United Nations. The new actors are frequently bound together in complex ways that change frequently.

Information technology empowers groups other than states to participate in developing and implementing international law. Political factions and separatists circulate messages through the Internet. Pressure groups now form almost instantaneously on the Internet to oppose actions in a given country, as university students know. International letter writing campaigns have gone electronic.

In the changing structure of international law, states exist in a global civil society that shapes the development of and compliance with international law. The sharp lines between public and private international law are blurring, the rigid divide between international and national law is fading, and the difference between the effectiveness of binding and legally nonbinding instruments in international law in changing behavior is under deserved scrutiny. I have developed these points elsewhere.

To clarify the role of international law in addressing environmental security, three substantive developments are important: the expression of fundamental norms (or values) among peoples to address the growing fragmentation and integration, the rise of international monitoring and tracking regimes for transborder transactions that affect environmental security, and the growing emphasis on compliance with international legal obligations.

Substantive directions

Norms as integrating fragmented communities

International law will bear an unusually heavy challenge in the decades ahead: to provide the norms that connect the many parts of our global society. Political theory tells us that viable communities need shared values, either globally or locally. They need to feel linked to each other. The new transnational elites need to share common values with each other and with the fragmented communities who are not directly part of the elites.

While the numerous decentralized communities could view international law as irrelevant and produced by elites, it is equally plausible that international law will be seen as providing the normative content and a voice for the needs of all groups who feel dispossessed, discriminated against, and deprived of basic human rights. Developments in human rights illustrate this, where television and advances in information technology have brought violations of the norms into living rooms everywhere. In the Helsinki process, international human rights law armed those who were fighting oppression. In central and eastern Europe in the late 1980s and early 1990s, environmental rights provided a rallying cry for those seeking democratic rule. Calls for environmental justice in the United States, calls that will likely be heard around the world, demonstrate the importance of norms in uniting and mobilizing people. Global communications can link disparate groups to express common values and ends.

International monitoring and tracking regimes

Scholars and policy analysts are pointing to unprecedented global threats to environmental security in the decades to come. One response may likely be unprecedented tracking of international transactions and monitoring of compliance with relevant international legal obligations.

Materials increasingly cross national borders, and transactions do so electronically. There may be a need for increased international regulatory tracking of dangerous transactions related to national security but also to environmental security, such as movements of nuclear materials and wastes, trade in chemicals, and transfers of hazardous technologies.[2] As the world becomes more fragmented, this is seen by many as essential for containing growing threats to the security of the planet. Technological advances will make near real-time tracking of transactions and movements of material possible. Highly sophisticated technologies are also available to track national compliance with certain international treaties, such as the Montreal Protocol on Substances That Deplete the Ozone Layer, and to assess their effectiveness. But as international monitoring and tracking is increasingly invoked to counter threats to environmental security, problems will arise from inroads on national sovereignty, invasions of individual and corporate privacy, and potential vulnerability to renegade actors.

Compliance with international law

Until recently, there has often been little attention to the nuances of compliance with international legal instruments. Traditionally, compliance is viewed hierarchically: governments join treaties and adopt national implementing legislation or regulations, with which domestic units comply. Compliance can be measured in a snapshot.

But, in fact, agreements evolve over time and, most importantly, compliance by countries changes over time and involves processes that cannot be captured by a hierarchical framework. States do not necessarily comply fully with their obligations, either because they lack the capacity or the political will or both. Compliance at the national level involves a dynamic process between governments, secretariats, international organizations (including international financial institutions), nongovernmental organizations, subnational units, and the private sector. Strategies to ensure the desired changes in behavior must be targeted toward *engaging* countries (Brown Weiss and Jacobson, Forthcoming 1998). This requires strategies that affect either their political will or their capacity. Strategies must be tailored to the specific agreements and the characteristic of the country.

It is often assumed that binding legal instruments are preferable to legally nonbinding instruments, since countries comply much better with the former. But there is reason to question this assumption. While binding legal obligations may provide explicitly for sanctions to counter violations, many agreements in areas such as environment rely exclusively, or almost exclusively, on other methods to secure compliance. There is no evidence that compliance with them is less, although for certain areas, such as trade, the threat of sanctions may have a very important deterrent effect. The reasons that induce countries to comply with international legal obligations—predictive and stable patterns of behavior, access to benefits, coordination of national actions, securing or maintaining a level competitive playing field—may also apply to nonlegally binding instruments. Since nonbinding legal instruments are growing much faster than binding ones and will be important for problems of environmental security, this issue needs further exploration and analysis.

Systemic issues: manageability and accountability

The emerging structure of international law raises two important systemic concerns that are particularly relevant for environmental security problems: manageability and accountability.

Manageability: Since World War II, there has been a legalization of the relationship among states. There are now over 33,000 international agreements registered with the United Nations, compared to 61 multilateral treaties recorded between 1918 and 1941. In addition, there are thousands of other international legal instruments not registered with the United Nations, and new rules of customary international law have emerged. As of 1992, there were over 900 international agreements or important non-binding legal instruments that were either addressed to environmental issues or contained important environmental provisions. Moreover, thousands of voluntary legal instruments have emerged among states and among nonstate actors. Many of the international agreements have mini-institutions associated with them, with individual secretariats, meetings of parties, and subcommittee activities. This growth in international legal instruments raises the question of whether the international legal system is manageable, both for developed and developing countries.

There are three important aspects to this issue: congestion, capacity overload, and the need for a systematic collection of international law.

• Treaty congestion. Such congestion can easily be seen in the environmental area, with more than 900 relevant international legal instruments. There is great potential for duplication, inconsistencies, and unnoticed but significant gaps. The Biodiversity Convention, Convention on International Trade in Endangered Species, International Tropical Timber Agreement, Desertification Convention, and the Nonbinding Forest Principles overlap in the areas they address. The Biodiversity Convention provides for essentially trumping conflicting provisions in other agreements. Problems of overlap also occur in other areas, e.g. the intersection of the London Convention of 1972 on marine pollution by dumping and the Basel Convention on the Transboundary Movement of Hazardous Wastes.

Moreover, there is considerable duplication in the international system in the sense that international agreements typically have separate secretariats, separate monitoring mechanisms, separate funds for financial and technical assistance, separate scientific advisory bodies, and separate reporting requirements. While there are legitimate reasons why this may be desirable, nonetheless there are also reasons to query whether the system can be made more efficient without sacrificing the specific needs of each agreement or the responsiveness of the institutional arrangements to the parties of each agreement.

The issue also arises in the context of dispute settlement, where there are increasingly multiple forums available for settling particular disputes. For example, oceans issues may go to the new Law of the Sea Tribunal or to the International Court of Justice, or other dispute settlement bodies attached to a particular agreement. Different bodies may give differing interpretations on similar issues, such as the validity of jurisdictional reservations to judicial settlement (as in the Turkish case before the European Court of Human Rights and the decisions of the International Court of Justice). This, in turn, may encourage forum shopping. In contrast to national legal systems, there is no international body that serves as the ultimate body of appeal.

But the proliferation of international agreements and forums for settling disputes also has a very positive implication: that more actors, both state and nonstate, are acting under the rule of law and are resolving disputes peaceably according to "the rule of law." International law is becoming central to community concerns across the world, and will be central to environmental security, in part because there are more international legal instruments defining its content in more subject areas and more forums available to resolve disputes. From this perspective, a hierarchy for determining law authoritatively might stifle the attractiveness of peacefully settling disputes by imposing costly and time-consuming procedures, or by discouraging creative resolutions.

Similarly, the solution to treaty congestion is not necessarily to forego negotiating new agreements, but rather to ensure that the highway on which the treaties operate is efficient.

• Capacity overload. The growing number of international agreements also raises a different aspect of treaty congestion: namely, capacity overload on governments at the national level and on nongovernmental organizations and other nonstate actors. The costs in time and resources in negotiating international agreements can be high. Four or five intergovernmental negotiating sessions of one to two weeks each during less than two years, as in the Framework Convention for Climate Change, place large demands on countries to staff and fund participants. The demands affect all countries, but are particularly severe for those countries with limited resources. While countries have sometimes established trust funds to help developing countries to participate in the negotiations, this remains unusual. Interested nongovernmental organizations and industry coalitions face similar time and resource demands. In part, the tendency to conclude nonbinding legal instruments among governments or voluntary codes in the private sector, which may require less time and fewer resources, reflect these pressures.

• Systematic collection of law. Finally, there is a growing need to develop a systematic collection of international law (Sohn 1995). It is difficult today to find all the relevant sources of law in any field of international law. Certainly to meet threats of environmental security, it would be useful to be able to locate relevant law. The information revolution can be helpful in providing the technology with which to compile and monitor the commonly held body of international law. We need to explore building a computerized data base that would include judicial and arbitral decisions from fora in specialized fields as well as important national court decisions bearing on international law. Information technology may also facilitate the chronicling of state practice to determine the development of rules of customary international law and otherwise help to maintain a consistent, commonly held body of international law and to monitor changes in it.

Accountability. States have always been accountable to each other as sovereign independent states for assuring compliance with international law. Moreover, states, in exercising their powers to tax, conscript, and form armies, for example, are accountable to their citizens in democratic governments. However, the many nonstate actors are not yet routinely or fully accountable for their actions. Many are constructive in their influence; others not. Their sheer number poses congestion problems.

On the one hand, participation by nonstate actors in the international legal system greatly enhances accountability in the intergovernmental system, because it can give a voice to citizens who would otherwise be unrepresented, ensure that actions taken meet local needs, counter effects of high-level governmental corruption, and therefore produce outcomes that maximize human welfare efficiently. Technology makes information readily accessible to groups and individuals across the world and empowers them. It can make governments and international organizations more transparent and accountable. In international environmental law, nonstate actors are now prominent participants, either formally or informally, in international negotiations, conferences of parties, monitoring measures, and other strategies.

On the other hand, nonstate actors are not subject to direct public accountability. Some nongovernmental organizations are membership based and accountable to their members, while others are loosely accountable to their funders, who may be dispersed. Spurious information, unrelenting pressures for special interest pleading outside the intergovernmental forum, unlimited demands for transparency, and similar concerns mean that pressures are building for at least informal guidelines of appropriate conduct. It may be in the best interest of leading nongovernmental organizations, who have contributed much to developing and implementing international law, to take the lead on this issue.

A second major issue of accountability stems from the emerging transnational standards and management practices being developed, largely in the private sector for the private sector, such as the ISO 14000 series, Responsible Care for the chemical industrial, and ecolabels for certain products. In most parts of the world, industries and corporations are accountable through the market system. Thus, nonstate actors should eventually find that consumer preferences both drive and limit what they can do. But accountability through the marketplace is tenuous and works imperfectly.

A major function of international law is to provide a process for legitimating norms. It is, therefore, important to construct processes for legitimating the norms developed by transnational industrial actors. Otherwise, no matter how wise the norms may be, they will not be acceptable in the long run. This may often mean giving a voice to governments and to the public in developing the norms, whether they be environmental management standards, ecolabels, or banking practices. The industrial sector may resist because the situation is moving too fast for meaningful consultation or because other actors are believed to be not sufficiently well informed and therefore could corrode and delay the process. In some cases, transparency of the process and public monitoring of the results may be sufficient to legitimate the norms. But unless the process for developing the norms is viewed as legitimate, the norms, even if sound, may ultimately not be accepted by the broader community.

As we address the many issues included within the rubric of environmental security, we will face an international legal structure that is changed from the classical form and that reflects the rise of a global civil society. It engages new actors and enlists important new resources, although to be sure it also raises new dangers. Just as environmental security has expanded our view of security, so is this emerging international legal structure better suited to the complicated international security problems that we face in the next century.

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Endnotes

1. This paper is based on the lecture, "The Changing Structure of International Law," delivered by the author as the Inaugural Lecture for the Francis Cabell Brown Professor of International Law, May 23, 1996. The lecture will appear in a book edited by Jessica Mathews, to be published by the Council on Foreign Relations. A modified version of the lecture is included in Mankind and the Environment: Papers in honor of Alexandre Kiss (Frison Roche, Paris, France, 1998)

2. John Steinbrunner has articulated a need for tracking for national security reasons in his research at the Brookings Institution. See unpublished remarks, Georgetown University Law Center, March 1996.

Towards a functional definition of "environmental security"

Braden R. Allenby

As demonstrated elsewhere in this volume, it is difficult enough to understand environmental and security issues in the post-Cold War era in their traditional sense given the accelerating rate of comprehensive change we are experiencing at the end of this century. It is doubly difficult, then, to understand what the possible integration of these two policy structures might mean. And yet, there is at least strong intuitive appeal to the possibility that "environmental security," at least in some sense, captures potentially important issues; that is, that the concept, whatever it is called, is substantively valid. Indeed, it is in practice an evolving policy initiative in the United States as well as elsewhere (e.g., Chinese air emissions contributing to acid rain in Japan).

Nonetheless, this is still little agreement on what, if anything, is included or excluded. The boundaries of the concept are indeterminate, and the core is poorly defined. More importantly, the cultural changes in the most relevant communities—environmental, national security, national defense, foreign policy, and related research entities—necessary to move from initial posturing and conflict to integration have yet to occur. An important part of this evolution is to move the discussion wherever possible towards discussion of substantive issues and case studies in the context of an intellectual framework acceptable to all relevant communities (or, as none of the communities are monolithic, a critical mass).

This requires an emphasis on two separate developments. First, it is necessary to reduce some of the ambiguity of the concept by better structuring it. Importantly, this process does not in itself imply there is greater or lesser validity to the concept; it only makes it easier to make that determination in a rational way.

Second, it is important to understand the important role that science and technology (S&T) will play, both by supporting the increased rationalization of the concept, and by developing an S&T capability necessary to carry out the policy in practice. In many cases, such an integrated modeling of relevant natural systems linked from local to regional scale, and short term to long term, will require new research and development (R&D) activities, and access to powerful modeling and computational resources. Part of the challenge of the concept, in fact, is that the necessary S&T even now pushes the boundaries of existing capabilities.

An important result of a better scientific understanding of these issues should be a filter mechanism that can provide at least a conceptual framework to support issue identification and prioritization. Resources, financial and human, are always constrained. Common sense thus dictates the policy principle that, all things equal, investment in relevant science and technology (S&T) should primarily be directed at creating a targeted S&T base to support specific critical elements of an enhanced national security mission, rather than scattered across all potential foreign policy issues, or even potential environmental security issues.

On a final note, cases and discussion in this paper will take the perspective of the United States. This focus aids in exposition, especially given the nascent state of the debate on the concept. Of course, the general principles elucidated below are equally applicable, with appropriate modification of specifics, to other nation-states and perspectives. Also, for ease of exposition, this paper will use the term “environmental security,” although the question of its validity and content is not assumed to be answered.

Components of the enhanced national security mission

Initially, it is important to make the critical point that different policy communities have very different understanding of the term “security.” Most basically, there are two fundamentally different views one can take about environmental security issues. The first, essentially a “global citizen” view, holds that any resource, energy, environmental, or biological perturbation of sufficient magnitude is appropriately considered a security issue, regardless of whether it directly impacts any specific country’s interests (see Figure 4-2 on page 46). Philosophically, this is in keeping with the integrated, regional and global nature of many of these perturbations, such as stratospheric ozone depletion, global climate change, regional, and global distribution of toxics, degradation of air and water resources, and loss of biodiversity (Turner et al. 1990; Graedel and Allenby 1995; Socolow et al. 1995).

On the other hand, the range of issues that potentially arise from a “global citizen” environmental security approach is virtually unlimited, and highly complex, and it is obviously impossible to focus on all of them at once. A filter that limits and prioritizes allocation of resources is a necessity for substantive progress. Moreover, the national policy of the United States, and its implementation by agencies and departments of the federal government, necessarily focus on issues of interest and concern to the citizens of the United States. This leads naturally to a state-centered definition, which may look outward globally, but does so from the perspective of, and reflecting the interests of, the specific state. Even this perspective is, however, not unitary. Some issues may be general humanitarian issues that do not become foreign policy or national security issues (e.g., some famines in Africa). Some may be foreign policy issues, but not involve traditional national security directly (e.g., negotiations over imports of threatened species). Only a few issues and circumstances fit within the category of national security. Even a state-centered focus, however, does not preclude international collaboration; indeed, any successful enhanced national security mission will require such collaboration.

Taking the U. S. focus as a starting point, there is no question that many different perturbations discussed under the general rubric of “environmental security” can, directly or indirectly, cause impacts to the United States. The term is very broad, and includes very different classes of issues that raise quite different operational implications. Accordingly, it is necessary to create a more rigorous framework to support issue prioritization. Attention and resources can then be focused on those impacts that have or well may have substantial security impacts on the country, in the sense that internal stability and/or international authority are challenged, or the probability of conflict, including if necessary military action, to protect the national interest is unacceptably increased.

The Cold War concept of national security was built upon a solid and sophisti-

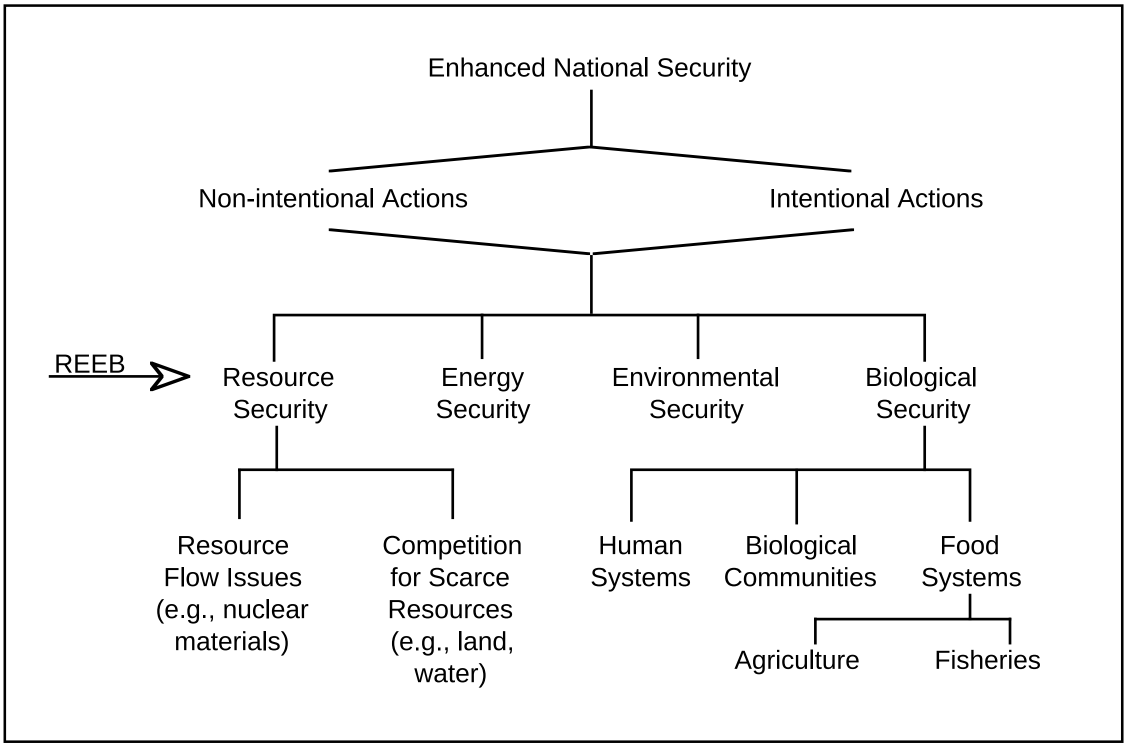


Figure 7-1. Components of the enhanced national security mission.

cated base of scientific and technological understanding, particularly of nuclear technologies. This facilitated rigorous definition, and prioritization, of elements of the national interest, and supported conflict avoidance and minimization efforts even in a highly adversarial environment. Analogously, issues included under the broad term "environmental security" also require a strong underpinning of scientific and technological understanding, a need that has yet to be addressed. In fact, even some of the proponents of the expanded definition may not yet recognize that this need exists.

This understanding, and a more rigorous definition of environmental security, will co-evolve over time. Currently, the term is actually over-broad and potentially misleading. It is thus appropriate to define an analytical framework that supports the evolution of the concept of enhanced national security into operational programs and projects. Viewed from this perspective, the environmental security dimension of the enhanced national security mission is more precisely an amalgam of four conceptually separate components: resource security, energy security, environmental security, and biological security (REEB). Although there is necessarily some overlap among these components, and between them and traditional security concerns, the conceptual separation is instructive (Figure 7-1). Where examples are given, they are illustrative: it is premature without further R&D and definition of the concept to view them as definitive.

1. Resource security involves two subcomponents: 1) local or regional competition for scarce resources, or 2) patterns of resource flows and use. Resource issues in either category become a resource security concern if they have the potential to give rise to political or military conflict of security concern to the United States. Competition for water resources in areas such as the Middle East, or the arid North American West (Liverman and O'Brien 1991; Gleick 1993; Kelly and Homer-Dixon 1995), or arable land in areas such as Chiapas, Mexico (Howard and Homer-Dixon 1995), are examples of competition for scarce resources which may raise security concerns for the U. S. (see also Percival and Homer-Dixon 1995a and 1995b). Managing flows of nuclear materials to avoid proliferation of weapons of mass destruction is an example of a resource security issue arising from patterns of resource flows and use (Center for Strategic and International Studies 1996).

2. Energy security involves the identification and maintenance of access to energy sources necessary to support continuation of U. S. economic and military activities. While military conflict deriving at least in part from competition over secure energy sources has already occurred, public interest in energy security as an issue has waned because many assume that energy security is already assured by existing U. S. policies and military capabilities. Moreover, the desire not to have to deal with energy security as an issue is fostered by the undeniable reality that it would be expensive to maintain a resilient energy posture (reduce energy use per unit Gross Domestic Product (GDP), research and develop alternative production technologies, maintain military preparedness to fight a second Gulf War) (Stagliano 1995).

Nonetheless, it is clear that a stable, sustainable, and affordable flow of energy is critical to all developed economies: in the United States, for example, energy fuel and services account for almost 10% of GDP, with derived benefits estimated to be more than half of the nation's GDP. Energy markets are, however, increasingly unstable, and thus energy security must be regarded as an increasing concern, especially as competition for available traditional energy sources grows more intense as global economic activity accelerates. Growth in demand, particularly in Asia, clearly threatens existing reasonable prices for, and access to, energy derived from various sources, particularly petroleum (Calder 1996; Romm and Curtis 1996).

Several points regarding energy security are worth noting. First, as with resources, absolute scarcity of potential energy resources is unlikely to be a concern; rather, rapid fluctuations in supply and demand, local and regional scarcities, and the long lag times required to shift among different energy production and consumption technologies, are the potential problem. Environmental and other social costs associated with energy production may also rise significantly as global energy markets expand substantially. Examples include greater frequency and amount of petroleum spills; increased leakage of natural gas from production, transportation, and storage facilities; and costs associated with management of nuclear power residual streams (the Yucca Mountain nuclear materials storage facility project in the United States has already cost some $1.7 billion [Whipple 1996]).

Additionally, because energy is among the most critical inputs into any developed economy, U.S. security can be threatened in two ways by even temporary energy shortages. The most obvious is directly (a scarcity domestically); equally important, however, is the potential for indirect significant impacts, as the economies of foreign trading partners are adversely affected. The U. S. economy is now so linked to the global economy that a significant perturbation to the latter could easily generate a recession, if not depression, in the United States, and at the least would be politically difficult domestically.

3. Environmental security involves the maintenance of environmental systems whose disruption would likely create national security concerns for the United States. Such issues could arise in either a domestic or foreign context. Examples might include releases of nuclear material in one state that, over either the short or long term, generate substantial impacts on other states (Bradley et al. 1996), or environmental degradation in one locality that are so intense as to generate substantial population migration or other conditions with the potential to create conflict situations of concern to the United States (cf. Gizewski and Homer-Dixon 1996). Thus, for example, environmental degradation in the former Soviet Union (FSU) has been identified by a number of experts as an important contributing factor to greatly increased migration throughout the region, which may generate possible political and military consequences (Feshbach, 1995).

4. Biological security involves maintaining the health and stability of critical biological systems whose disruption would likely create national security implications for the United States. Such systems could be either domestic or foreign. The two most obvious classes of systems are 1) human populations, and 2) food systems, including crops, livestock, and fisheries. A third, less obvious class of systems is biological communities of various kinds, such as wetlands, forests, or critical habitat, which frequently provide important "natural infrastructure" functions, such as flood control or fisheries breeding areas. A particularly difficult set of issues in this latter class arises when activity in one country affects an internal biological community, whose disruption has extra-territorial effects.

A domestic example of a biological security incident would be the release, either deliberate or as a result of changing climate patterns, of a pathogen that attacked a major food crop. A foreign example that combines resource security with biological security would be changes in precipitation patterns in China that disrupted water supplies (a resource issue), which in turn resulted in significant negative impacts on crop success, thereby generating both economic disruption as China accessed world markets in response, and potential conflict situations if strong pressure for population migration were created. An example of the third class would be when deforestation of the upper reaches of a watershed for a major river reduced the ability of that biological community to absorb and retard stormwater, generating unprecedented flooding in downstream nations (as with India and Bangladesh).

A potential biological security issue worth noting involves potential change in pathogen activity and distribution. Increased pathogen exposure and virulence due to changing cultural patterns (e.g., global travel), rapid evolution of bacterial resistance to antibiotics, and changing climate and human settlement patterns has been an increasing concern among experts (Pirages 1996). It is generally not realized how many previously unidentified infectious agents are still being detected. Since 1982, for example, 11 human diseases have been newly identified, including human immunodeficiency virus, hepatitis E virus, hepatitis C virus, Venezuelan hemorrhagic fever, Brazilian hemorrhagic fever, human herpesvirus 8 (Keposi's sarcoma), and HTLV-II virus (hairy cell leukemia). The possibility of significant domestic impact on human or biological system health as a result of new pathogen activity is, indeed, one that cannot be ignored. It remains true, however, that the 10 infectious diseases causing the most fatalities, with the exception of HIV/AIDS, tend to be clustered in developing countries (acute respiratory infections, 4.4 million deaths in 1995; tuberculosis, 3.1 million; diarrheal diseases, 3.1 million; malaria, 2.1 million; hepatitis B, 1.1 million; HIV and measles, greater than 1 million each; neonatal tetanus, .5 million; whooping cough, .335 million; and roundworm and hookworm, .165 million (data from *Science*, 31 May 1996, p. 1269)).

The potential for significant national impact from altered pathogen behavior and distribution is thus apparent, although immediate threat is less obvious, as is the appropriate role for traditional security-oriented organizations. This suggests that implementation of a balanced research program, with specific attention paid to the pathogens which might pose a threat to the United States, along with the conditions, existing or foreseeable, under which they might do so, would be an advisable course of action, offering efficient resiliency of response—but that traditional response agencies such as the Centers for Disease Control and the National Institutes of Health, rather than the national security apparatus, are the appropriate vehicles for such a response.

Intentional and unintentional perturbations

A second classification of potential REEB perturbations, differentiating between intentional and nonintentional activities, is useful in constructing an enhanced national security structure. Both intentional and nonintentional activities must be considered as part of an enhanced national security mission, but there is an important distinction. Nonintentional activities may or may not rise to the level of resource, energy, environmental, or biological security issues. Intentional ones, on the other hand, frequently will, as they are, by definition, extensions of another state's policies and interests through deliberately chosen actions. Moreover, they are more likely to be difficult to counter, and more likely to constitute a significant threat, as they presumably have been chosen to be effective.

The ability to generate such threats is augmented by the characteristics of the natural systems upon which they are based: local actions can frequently perturb regional or global systems, thus permitting a state to project international threats based on internal activities. The Chernobyl incident is an unintentional example that involved only one facility but affected much of Europe (Shcherbak 1996). Moreover, because of the technically complex nature of such systems, a relatively simple perturbation can have numerous and complex potential effects that are virtually impossible to counter once the system is perturbed.

In some cases, however, particularly where conflict has already begun, the distinction between the two may be difficult and ultimately not meaningful. For example, a concern arose during the recent Gulf War that the Iraqis would burn so much oil that the resultant particulates would lower global temperatures and sunlight penetration, creating a widespread ecological disaster. Rapid assessment by the U. S. Department of Energy national security laboratories indicated that such a threat was groundless, but, had such an S&T assessment capability not been available, the impact on planned military initiatives in the area might have been substantial. Moreover, even though the larger threat was groundless, the environmental conditions that were created during the conflict by the intentional burning of petroleum by Iraqi forces generated difficult military and personnel conditions, and the possibility that the health of U. S. and allied troops was affected is still under investigation. Under these circumstances, the intent of the Iraqis is relatively unimportant.

Structuring an enhanced national security mission

The Cold War national security policy structure consisted of two closely linked primary components: an S&T base that provided military capability, threat definition, and technological support for collaborative threat reduction (e.g., monitoring treaty compliance); and a policy component supported by that base. The structure required to support an enhanced national security mission is analogous, but perhaps not as widely recognized. In particular, it is necessary to build an S&T capability to support the development of the resource, energy, biological, and environmental components of national security.

Figure 7-2 illustrates the policy/S&T framework for an enhanced national security mission. The first step in creating the S&T base for a particular issue is to understand the dynamics of the underlying physical system, which might include, for example, generating a model of its behavior. Depending on the system, such models may be fairly simple (as, perhaps, where resource competition involves land allocation that is more a matter of culture, history and politics than the underlying characteristics of the land itself, as in Chiapas, Mexico, where the Zapatista National Liberation Army is challenging the state). On the other hand, they might be quite complex, as where, for

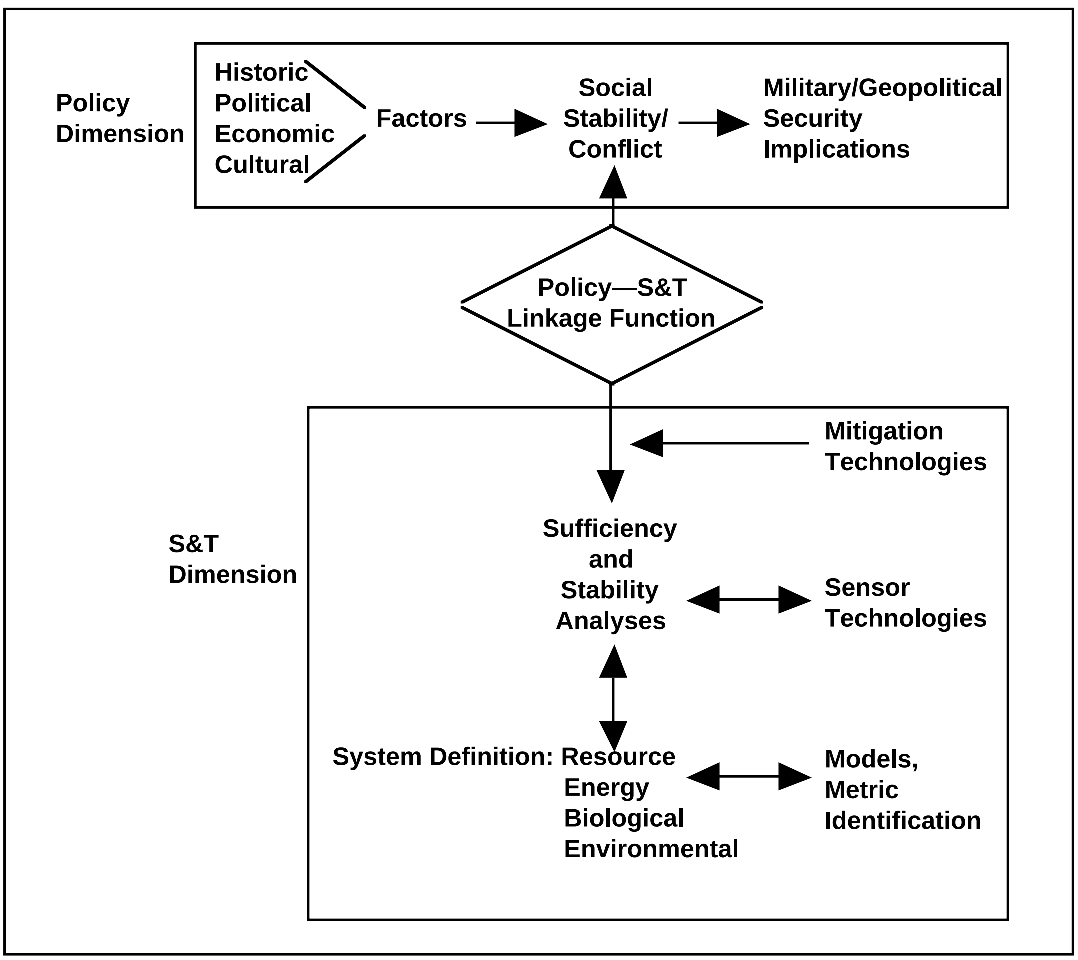


Figure 7-2. Enhanced national security policy structure.

example, an attempt to understand potential future precipitation patterns and water management systems in Asia would be part of a confidence building program with the goal of ensuring that crop failures and food shortages did not result in destabilizing population migrations. Such a model might have to link together a number of sub-models covering a wide spatial and temporal scale.

As understanding of the system is gained, metrics by which one can evaluate its evolution over time can be developed. Ideally, such metrics will support the ability to predict when the system might be approaching instability, a particularly important concern since patterns of human activity tend to be predicated on the assumed stability of underlying natural systems, and much human effort is essentially aimed at engineering such stability in inherently variable systems. Thus, for example, much of the manipulation of rivers in the Middle East is intended to stabilize their annual supply of water at the highest possible level (these riverine systems are by nature highly unstable), as well as to expropriate as much of the resource as possible. Instabilities in natural systems, such as precipitation patterns, changes in groundwater flow, or other perturbations that either increase the interannual variability, or reduce the amount of water that can be reliably produced, can under the circumstances generate the potential for resource scarcity conflict.

Once the system is defined and its behavior and stability assessed, sensor technology to provide input and track system evolution against the appropriate metrics can be deployed. Depending on the parameter, sensor systems may be either ground- or satellite-based. A great deal of sensor technology has been developed for military applications and is resident in the national laboratories, and the opportunities to apply such technology to enhanced national security issues is both substantial and largely unexplored.

Finally, understanding the physical systems relevant to a possible security issue provides an opportunity for development of mitigation technologies, including if appropriate traditional remediation technologies, before the potential conflict develops. In fact, with luck the issue can be identified, defined, and resolved within the context of a collaborative S&T effort without rising to the policy dimension at all. For example, if crop failure resulting from changes in precipitation patterns is a concern, an entire set of mitigation efforts is possible, depending on the time scale. With several years warning, new crops and cultivars that are more robust under the predicted conditions can be introduced. Even with less warning, water recycling, demand reduction, and water storage technologies can be deployed. At the least, appropriate food transportation, storage, and distribution facilities can be prepared. Additionally, of course, a number of mitigating policies can be adopted by the international community based on the projected perturbation, including, for example, more planting of grain in other exporting countries to buffer the anticipated demand.

Once the S&T dimension of a particular issue or set of issues is established, it is then possible to integrate the results into a robust security analysis and policy. While it is possible that a natural system perturbation, in itself, could generate national security implications, it is more likely that in many cases the national security effects of perturbations will arise only when they occur in conjunction with more traditional indicia of state instability, which themselves reflect specific historic, political, economic and cultural factors. Thus, the S&T base does not replace, but is a necessary component of, enhanced national security policy considerations and analyses.

Experience indicates that the linkage between the S&T and policy dimensions, while conceptually apparent, is frequently weak or less effectual than possible. This might be particularly difficult as the organization providing the S&T capability will in most cases not be the organization making the policy decisions. It is therefore worth emphasizing the need to establish a clear linkage function between the S&T and policy dimensions, as shown in Figure 7-2, at the outset.

Like any effort to change existing institutions—in this case, by integrating environment with existing policy and organizational systems—it is highly desirable to minimize the degree of change to that which is absolutely necessary, and to draw on existing structures to the extent possible. It is likely that the challenges of an enhanced national security mission will, over time, call forth new organizations with the broad, multidisciplinary mandates implied by the complexity and cross-cutting nature of such a mission. In the short term, however, it is easier and less confrontational if the organizational structure for an enhanced national security mission tracks that already existing, with appropriate enhancements to reflect the extension of the mission.

This process has begun in the United States, with the Department of State taking the lead, and, based on a Memorandum of Understanding signed in 1996 by the U. S. Environmental Protection Agency, the Department of Energy, and the Department of Defense, support being provided by other entities. The complex nature of the potential threat in this case, however, suggests that once a robust support structure for REEB issues is in place, it will require the collaboration of a number of departments and agencies, including, for example, the Department of Agriculture, NASA, the Department of Commerce, and the Department of the Interior. Moreover, in the vast majority of cases, the foreign counterparts of these agencies, as well as international agencies such as NATO, should also be included in the collaborative effort to address these issues as appropriate.

An important part of the cultural change implied in the process of integrating environment with other policy and organizational structures is ensuring that meaningful authority relationships are established within institutions. It is not enough to simply start a new “Office of Environmental Security” or the equivalent. Rather, it is necessary to ensure explicit ownership of the program by an appropriate, and appropriately powerful, office within each participating agency. The scope of the office should be both broad enough to allow it to manage the program as a whole, and important enough organizationally to ensure that REEB hasn’t been just superficially adopted, but effectively sidelined, by the bureaucracy (as some have argued has happened to some extent in the U. S. Departments of State and Energy).

It is also important to note that institutionalization of the enhanced national security mission will require establishing new collaborations, not just among U. S. departments and agencies, but with both friendly and potentially competitive states, a program that can build on much existing work, but in many cases will go beyond it. Here, also, the difference between intentional and nonintentional REEB events is important: collaboration will undoubtedly be more difficult in the former than in the latter case. Most difficult, perhaps, may be those issues, such as nuclear material management, that cut across both military and traditional security (e.g., nonproliferation and nuclear smuggling concerns), and REEB, civilian-oriented, enhanced security (e.g., nuclear energy production) arenas.

Prioritization of enhanced national security issues

The most important initial focus of the enhanced national security mission will be on existing or foreseeable intentional threats, and on those nonintentional issues that have already given rise, or contributed to, national security concerns. An example of the latter is provided by the well-known issue of water quality, and water reallocation, in the Middle East peace process (Kelley and Homer-Dixon 1995). Another example is North Korea, where nuclear material stocks and flows are of significant proliferation concern, and (alleged) food shortages resulting from unusual precipitation patterns and flooding, may be creating destabilizing conditions that, given the posture of the state, may lead directly to initiation of military conflict.

These conditions, which almost by definition are giving rise to current national security concerns, must be addressed on an immediate basis. The value added to them, however, by the REEB approach is to offer a framework within which enhanced understanding of the underlying physical systems, and perhaps technology development and deployment efforts, can be developed as a part of existing policy initiatives to reduce tensions and avoid escalation of conflict. Response to the North Korean situation, for example, has already included transfer of energy production technology designed to increase that state's energy security. Response to the food shortage issue might include not just the immediate response—provide food—but development and deployment of a more sophisticated conflict avoidance S&T strategy, to include developing models and sensor systems (probably satellite based, under the circumstances) that can help predict when perturbations in underlying physical systems could impact food production and distribution.

The real advantage of the REEB approach, of course, is in its ability to reduce the possibility, severity, and expense of future national security impacts and conflict. If this promise is to be achieved, the purpose of the REEB enhanced security mission must be kept in mind. The enhanced national security mission is not intended to cover all identifiable perturbations, or even the full universe of foreseeable impacts of REEB perturbations on the United States or its citizens. Rather, it is to support a prioritized approach to those regions and issues that, at least initially, appear to offer the greatest potential impacts on the security of the United States.

One can identify several prioritization mechanisms to be used in tandem. It is apparent that some regions are more critical to U. S. national security than others. Moreover, some issues will be of more importance to the United States than others: nuclear material flows, for example, will be a consistent resource concern globally. Finally, traditional indicia of environmental impacts—including the duration, severity, and geographical scope of the insult, and the technical difficulty and expense of mitigation—will also be important in prioritizing enhanced national security issues.

Application of these prioritization mechanisms to the set of potential issues cannot be done rigorously a priori. It is possible, however, to construct a matrix using these guidelines (Table 7-1) that links five geographic areas of self-evident critical geopolitical interest to the United States—China, Mexico, the former Soviet Union, Southeast Asia (including India and Pakistan), and the Middle East—with the four REEB categories. Where applicable, within each cell examples of issues that would appear to

Table 7-1. Possible initial focuses for enhanced national security initiatives.

	Resource Security	Energy Security	Environmental Security	Biological Security
China	•nuclear materials •commodity consumption patterns •water	•petroleum demand •petroleum supply •nuclear energy systems	•environmental costs of economic growth	•crop stability and food demand growth •population stability
Mexico	•water •land distribution		•environmental costs of economic growth	•crop stability •pathogen systems •population stability
Fomer Soviet Union	•nuclear materials	•nuclear energy production technology	•environmental costs of economic growth •nuclear waste issues	•population stability
South East Asia	•nuclear materials •water	•petroleum demand •petroleum supply •nuclear energy systems		•de-mining •crop stability and food demand growth
Middle East	•nuclear materials •water	•petroleum supply		

be the most pressing are identified. Similar matrices could easily be generated by other countries as well.

While this structure should not be interpreted to imply that other geographical areas, or REEB issues, are not of concern, significant instability in any of these regions could have immediate and serious foreign policy implications for the United States. The mechanisms by which REEB forcing functions might impact states may vary— population migration, increased state instability—and the effects on the United States could be either direct (e.g., increase in NAFTA population migration, or diversion of nuclear material to terrorist organizations) or indirect (e.g., instability in Asia or China causes regional economic dislocation, which in turn generates recession or depression in the United States). Nonetheless, the potential impacts of these particular issues on the United States and its citizens are, by-and-large, both apparent and potentially significant. To illustrate this point more specifically, two initial case studies can be suggested.

Case study number one: water and food in Mexico

Global population migration, both internal and external to existing states, is a continuous and probably inevitable phenomenon. In most cases, it will not raise national security issues for the United States, although it may call for humanitarian foreign policy responses. There are a relatively few cases, however, where such migrations may have such direct impacts on the United States as to give rise to legitimate national security concerns.

One class of events that can give rise to such migrations is perturbations to natural systems that, in conjunction with state resource management regimes, give rise to crop failure and food shortages, and hence discontinuous increases in migration from affected rural areas. Thus, for example, a change in precipitation patterns (flood or drought), or failure of irrigation sources because of aquifer drawdown, combined with inadequate planning or state response, might generate substantial migration pressures that could prove internally destabilizing or generate external conflict. The two states where such a pattern could most obviously raise enhanced national security concerns for the United States are Mexico and China, with other situations arising for unique reasons (e.g., North Korea crop failure generating pressure on the state to initiate foreign adventurism). The case of Mexico will be used as an illustration of this class of conditions.

Mexico is currently undergoing rapid economic and political evolution as it adjusts to the accelerated regionalization of its economy, partially as a result of the North American Free Trade Agreement, and concomitant political evolution away from the paternalistic one-party system that has characterized its governmental structure since World War II. Peasant technologies little changed for centuries, especially in the agricultural sector, coexist with modern industrialized facilities owned by transnationals competing in global markets. Cultural and legal systems that embed traditional class structures and support land-owning elites are increasingly challenged by modernist reformers, a conflict that in Chiapas led to armed confrontation between the Zapatistas and the state (for a discussion of the relationship between water and land resources, and the Zapatista rebellion, see Howard and Homer-Dixon 1995). Under these already somewhat unstable circumstances, crop failure as a result of water quality and/or quantity limitations may be a trigger for substantially increased internal unrest and consequent migration.

The national security threat implicit in this situation is twofold. Most obviously, the disparity in economic conditions between many areas in Mexico, and the wealthier districts in Mexico and the United States, has generated substantial migration, both internal, and between the United States and Mexico. The latter has already led to political conflict within affected U.S. jurisdictions (e.g., Proposition 187 in California restricting availability of public services such as school for illegal migrants, reflecting a widespread backlash in that state against migration from Mexico), and between the U.S. and Mexico. Violent incidents arising from efforts to restrict illegal immigration, including one involving alleged beatings of such migrants by law officers, are on the increase. Political reactions in the U.S. involve increased xenophobia, increased social tension, especially in border areas in California, and efforts to impose restrictions on migrants that have the effect of encouraging discrimination against American citizens of Hispanic descent.

Second, NAFTA is both a continuation, and a recognition, of a trend towards a regionally integrated economy including Canada, the United States, and Mexico (and perhaps others such as Chile). Disruption of these growing economic relationships would be costly both politically and economically, and would have the potential to generate a negative feedback loop: increased economic hardship in Mexico would lead to increased migration pressure, which, in turn, would exacerbate the political and economic disruption of existing NAFTA arrangements.

In both cases, an important forcing function for destabilization in an already difficult situation (e.g., a weakened state in a period of economic and political transition), and consequent migration, would appear to be perturbations to available water resources. Policies that more rigorously define, and concomitantly provide the basis for reducing, that forcing function are therefore desirable, all else equal. As in Figure 7-2, these policies will fall into two dimensions: the familiar policy dimension, and the less familiar S&T dimension.

More specifically, what S&T base should be developed to help support the stability of existing population patterns in Mexico and the border areas of the United States? The following discussion, as summed up in Figure 7-3, is suggested as illustrative: it is not definitive because, of course, a full initial assessment has not been done, and development of such a base will be iterative in practice. It is also important to confirm ab initio the obvious point such an S&T research program must be a fully collaborative effort with Mexico.

1. A key driver for population migration is agricultural failure, either real or perceived (that is, urban or United States life being perceived as increasingly desirable compared to the rural alternative). This in turn generally arises from patterns of distribution of two key resources—water and land—given existing populations and expectations. The linkage between the S&T dimension and the policy dimension thus flows through these categories. Both dimensions must be understood if the national security concerns are to be mitigated.

2. The S&T research program begins with development of a set of models that can be used to identify geographical and technological areas of greatest concern (e.g., where are resource conditions most marginal to begin with, and is there a crop or set of crops which are least stable under prevailing conditions?). Such a system might begin by looking at existing precipitation patterns at a relatively high level with a global or, more likely, mesoscale model. Then, a set of subsystem models of crop distribution and response, soil systems (the pedosphere), localized precipitation patterns, runoff and watershed response, and groundwater systems would be used to link precipitation with ability to support current agricultural systems, and determine whether, and to what extent, instability in precipitation patterns could generate meaningful agricultural disruption (i.e., disruption that would be significant enough to generate substantial pressures for migration or other potential impacts). Throughout this process, uncertainties of all kinds that might impact the prediction should be identified.

3. Once the baseline systems, including modeling and data components, are in place, a predictive capability would be built. The essence of this activity would be to identify potential instabilities in resource availability before they occur, determine whether they would be meaningful if they occurred, and identify uncertainties associated with the prediction (some of which, like poor data, might be reduced by further research, while some, such as chaotic behavior of natural systems, might be irreducible within certain boundaries). For example, is it possible to tell from an integrated assessment of data and models when Mexican precipitation patterns in key areas are becoming unstable in such a way as to impact critical agricultural activities before the fact? As Figure 7-3 indicates, answering such questions involves integrating models of many different kinds, which may operate over very different spatial and temporal dimensions. This is a nontrivial challenge, and may not be possible, at least at first, beyond one or two years, but it is an important step to support the development of mitigation technologies.

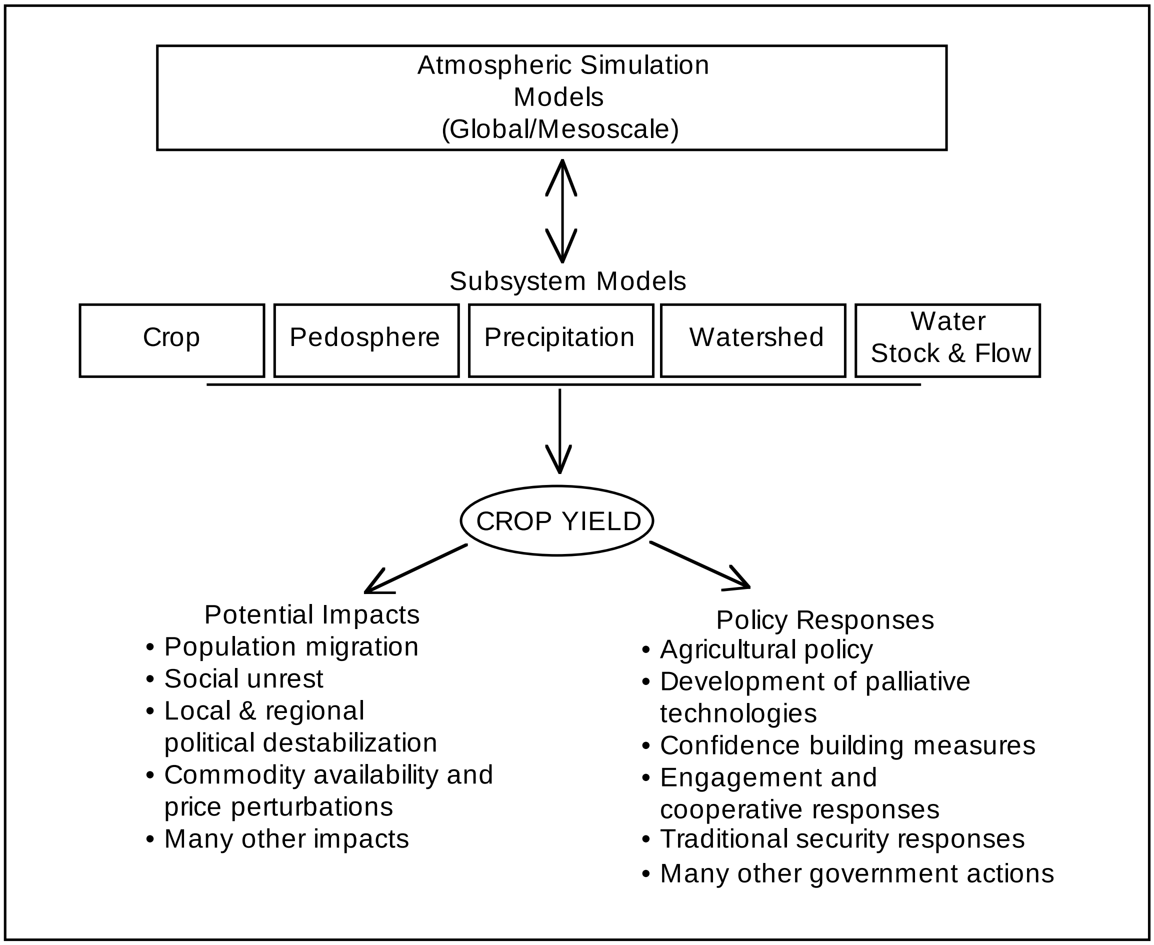
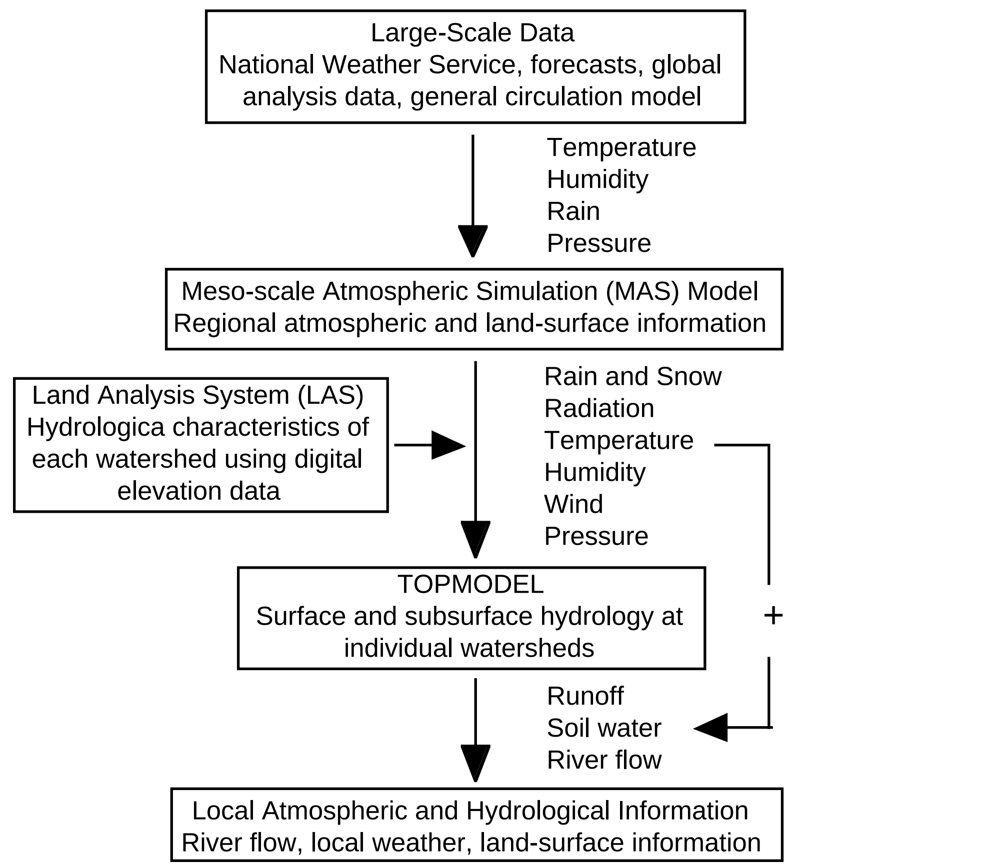


Figure 7-3. Building a science and technology base: water/food case study.

4. Concomitant with S&T system development and deployment is the need to deploy the appropriate sensor systems to monitor the physical system's state and performance. One might, for example, need data not just on precipitation and surface water flows, but on soil moisture content, vegetation stress, nutrient availability, and other parameters. Such sensor systems would probably include a satellite-based component, but, as always, ground-based verification of satellite data, and independent data generation regarding parameters that cannot be determined by remote sensing technologies, would be desirable.

5. The final step would be to develop and deploy mitigating technologies, which could range from engineering new varieties of existing crops, to introduction of new species entirely, to water or resource recycling or replenishment technologies. This step in particular must be linked to policy and state initiatives, as technology is a cultural as well as an engineering phenomenon, and inappropriate technologies may be perfectly apt, but are unlikely to be successfully deployed. Additionally, the economic dimensions of such shifts in technology may be complex in themselves. Again, collaborative effort is an obvious key to success.



*As developed and in use at Lawrence Livermore National Laboratory, Livermore, California

Figure 7-4. Coupled atmosphere-riverflow simulation system.*

The S&T set of activities would both inform, and be taken concomitantly with, appropriate policy initiatives. Ideally, they will permit the development of an increasingly sophisticated capability for collaboration and conflict avoidance, a particularly important issue in this case study, where the U.S. national interest in a secure and stable southern border is obvious. It is worth noting that such integrated models are currently being developed for a number of uses; Figure 7-4 is a schematic of an integrated coupled atmosphere-riverflow simulation model developed at Lawrence Livermore National Laboratory to help manage regional water systems.

Case study number two: nuclear materials

Nuclear materials are an example of a resource security issue that cuts across both traditional and enhanced national security interests, and includes significant energy security and biological security dimensions. Their inherent characteristics, uses, management, and impacts as improperly handled waste raise some of the most difficult and complex issues in the modern world. They are the basis for nuclear weapons, which previously were reserved to a limited number of states, but are now potentially available to terrorist organizations. They also are the basis for nuclear power, a technology which almost certainly will be increasingly deployed in the future, especially in Asia where economic expansion is driving an almost desperate increase in demand for energy production. The science and technology surrounding them in virtually any application is complex and arcane (Figure 7-5 provides a high level overview of nuclear materials flow), while the politics are polarized and bitter, whether the use is military or civilian.

Nuclear waste, whether in the United States, the FSU, or, increasingly, in Asia, potentially poses some of the most serious real risks associated with environmental pollution, and cleanups are both expensive and technically challenging—where they can be done at all (Bradley et al. 1996). Some contamination incidents—Chernobyl being the classic case—have caused extensive regional contamination which, had it not obviously been unintentional, might in itself have been a trigger for conflict. Even though unintentional, the impacts were enormous: within the Ukraine alone, 135,000 people were displaced within 10 days as a direct result of the incident, a figure that has since grown, and over 5% of that state's area remains significantly contaminated (Shcherbak 1996). The continuing destabilizing effects of that incident are demonstrated by the fact that, even now, the Ukrainian government, in a severe economic crisis, must continue to spend more than 5 percent of its budget in dealing with the continuing impacts of Chernobyl, including, for example, providing emergency housing to over 3 million directly affected people in Ukraine alone.

Dealing with nuclear materials issues is difficult in part because of their military (and terrorism) implications: civilian stocks and flows of such materials are linked inevitably with military and security concerns, and the potential for "environmental terrorism": a terrorist group would not need to explode a weapon, but could simply distribute radioactive materials widely in a heavily populated area, to achieve an impact (Center for Strategic and International Studies 1996).

Of course, a number of scientific, technical, and political efforts have been made to reduce the various risks that nuclear materials pose in various military and civilian applications, and a number of national and international organizations, including the International Atomic Energy Agency (IAEA) are active in supporting that goal as well. Nonetheless, the effectiveness of such efforts is limited by activities of rogue states (e.g., North Korea, Iraq), and a lack of resources (e.g., to provide alternative energy production sources to replace allegedly unsafe reactors, or support IAEA activities at a sufficiently high level).

More fundamentally, increases in nuclear power production are projected, especially in Asia; Table 7-2 shows that as of 1993 there were 441 units operating globally, with another 86 planned. These 1993 figures understate those that are now contemplated by developing countries such as China, which currently has 14 new units either planned or under construction, but probably overstate those planned in the former Soviet Union (FSU), thus demonstrating the volatility of such projections (see DOE EIA 1996, pp. 57-64, for a recent summary of current nuclear power capacity projections). When combined with a lack of knowledge about the nuclear materials system as a whole, these trends clearly indicate a potentially substantial increase in future national security risks associated with global nuclear materials management.

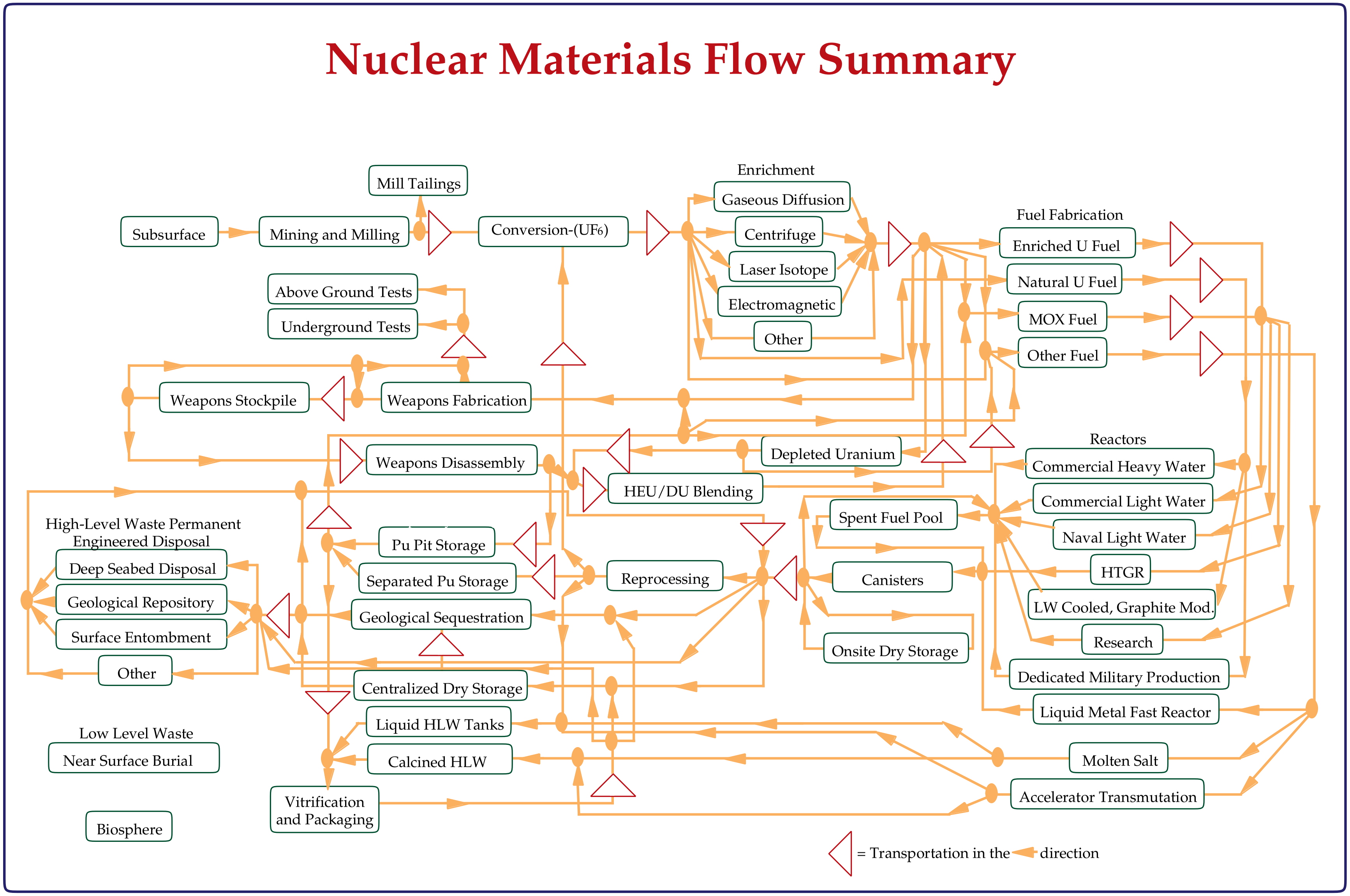


Figure 7-5. Nuclear materials flow summary.

Table 7-2. Reactors: operable, under construction, and planned (1993).

	Operable		Under Construction		Planned		Nuclear Generation in 1992	
	Units	MWe	Units	MWe	Units	MWe	TWh	% of Total
Agentina	2	1005	1	745	0	0	7.08	14.8
Bangladesh	0	0	0	0	1	300	-	-
Belgium	7	5834	0	0	0	0	40.09	59.9
Brazil	1	657	1	1309	0	0	1.75	0.8
Bulgaria	6	3760	0	0	0	0	11.5	32.5
Canada	22	16393	0	0	1	450	81.78	16.4
China, Peoples Rep	2	1284	3	2184	5	0	-	-
Czech Repulbic	4	1728	2	2000	0	0	12.25	20.7
Egypt	0	0	0	0	2	2000	-	-
Finland	4	2400	0	0	0	0	18.2	28.9
France	58	61899	3	4548	7	10150	321.7	72.8
Germany	20	22426	0	0	0	0	158.8	34
Hungary	4	1840	0	0	0	0	13.98	44.6
India	10	1733	8	2100	8	2880	6.33	2.1
Israel	0	0	0	0	1	950	-	-
Japan	48	38541	7	6925	15	16195	214	34.7
Kazakhstan	1	150	0	0	0	0	-	-
Korea, Rep of	9	7624	7	6079	7	6700	56.53	43.2
Lithuania	2	3000	0	0	0	0	14.64	78.2
Mexico	1	675	1	675	0	0	3.92	3.2
The Netherlands	2	539	0	0	0	0	3.21	5.4
Pakistan	1	137	1	310	0	0	0.55	1.2
Romania	0	0	5	3530	0	0	-	-
Russia	39	21926	3	3000	35	26496	119.6	11.8
South Africa, Rep of	2	1930	0	0	0	0	9.29	6.2
Slovakia	4	1760	4	1760	-	-	11.05	49.5
Slovenia	1	664	0	0	0	0	3.77	20.9
Spain	9	7400	0	0	0	0	55.73	35.5
Sweden	12	10158	0	0	0	0	61.0	43.3
Switzerland	5	3141	0	0	0	0	22.23	38.7
Taiwan	6	5144	0	0	2	2000	32.5	25.7
Turkey	0	0	0	0	0	0	-	-
Ukraine	14	12808	3	3000	0	0	73.75	29.4
UK	35	13063	1	1258	2	2600	48.44	18.1
USA	110	105055	5	6212	0	0	606.3	21.7
TOTAL	441	354674	57	45635	86	74521	2009.69	

An alternative scenario, however, based on the obvious recognition that safe global management of such materials is an important component of U.S. national security, would develop and deploy an S&T strategy that would both reduce risks, and, in many cases, provide an important vehicle for developing collaborative and confidence building exercises with other states (an important goal given that many of these states are either actually or potentially nuclear powers). Such a program would consist of several major components.

1. Construction and maintenance of a global data base and model system capturing the stocks and flows of as much nuclear material as possible. Such a system should be driven by a need to understand the physical structure of the "industrial metabolism" of these materials, not by, for example, relatively arbitrary regulatory distinctions between different kinds of "wastes", or regulatory regimes. It should be as complete and transparent as possible, recognizing that, at the margin, military security concerns will undoubtedly arise.

2. Development and deployment of sensor and materials security systems globally that can help assure the integrity of nuclear material storage and management, and prevent theft or diversion into informal channels.

3. Sponsorship of regular technology transfer activities, whereby global nuclear operations, particularly nuclear power and fuel cycle activities, can all be raised to world class safety and risk reduction levels.

Conclusion

This paper has attempted to provide more rigor to nascent efforts to integrate environmental issues and national security structures, a policy evolution that reflects the increased complexity and challenge of both anthropogenic environmental perturbations and the post Cold War geopolitical environment. It thus proposes a more rigorous definition of the components of the enhanced national security mission—resource security, energy security, environmental security, and biological security—as well as suggesting a more targeted approach to identifying the circumstances under which U.S. national security is actually at issue. Two case studies, one involving collaboration with a neighboring state, and one involving global resource security issues, are used as illustrative case studies.

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Perspective: Department of Energy

Abraham E. Haspel

The definition of "environmental security" has recently been, and will continue to be, a subject of interest to government leaders. This interest is founded on compelling evidence of the relationships between environmental problems, human health concerns, and economic and political instability.

While it is useful to plow this ground and to develop a greater understanding of the real consequences of environmental degradation, it is not necessary for all interested parties to have exactly the same definition of environmental security.

The unique perspectives of the individuals and organizations engaged in addressing critical environmental and security concerns will necessarily color that person's or group's definition. Further, the definition of environmental security may vary from region to region and may encompass a series of problems or stresses that stretch across a time continuum. Some environmental security issues are of immediate concern, while others are mid- or long-term in scope.

What is essential, however, is that we agree on the need to *consider the environment a key component of regional and national security* as we forge a vision for U.S. engagement in the world, and that we use this principle to create receptivity for the democratic institutions needed for a peaceful globe.

Although we are in the early stages of formulating a U.S. vision for defining and dealing with the critical intersection of environmental and security concerns, environmental conditions have long been a factor in regional and even global stability. Consider the fact that throughout history, most armed conflicts have involved territorial claims and disputes, particularly over territory that affords a plentiful water supply, arable land, and ownership of minerals and precious metals. In the new, post–Cold War world order that is emerging, we are again shifting our focus to environmental conditions that affect the quality of life and potential for prosperity worldwide, namely, food, fuel, and water, and people's health and safety. It seems as though everything old is new again.

The Clinton administration's cognizance of the important connection between environmental conditions and U.S. security is evident in both domestic and foreign policies. Domestic military base cleanup, the remediation of radioactive waste, and clean air, water, and land programs are strongly supported. The White House also recognizes the importance of environmental stresses in the global picture. The 1996 National Security Science and Technology Strategy, published by the White House Office of Science and Technology Policy, cites numerous examples of the need to consider environmental conditions as an element of stability and security. The strategy states: "Regional or civil conflicts, hastened or exacerbated by environmental stress, could involve the United States in costly and hazardous military interventions, peacekeeping, or humanitarian operations." (NSSTS 1996)

The Gore-Chernomyrdin Commission with Russia, the Gore-Mbeki Commission with South Africa, and the new Gore-Kuchma Commission with the Ukraine all include a strong focus on energy, the environment, and other health and safety issues. And, of course, the administration's commitment to strengthening the Framework Convention on Climate Change is a primary example of the importance we associate with environmental issues.

Earlier this year, Secretary of State Warren Christopher instructed State Department officials to incorporate environmental concerns as a core element of U.S. foreign policy. In a speech delivered in April 1996 at Stanford University, Secretary Christopher said: "The environment has a profound impact on our national interests in two ways: First, environmental forces transcend borders and oceans to threaten directly the health, prosperity, and jobs of American citizens. Second, addressing national resources is frequently critical to achieving political and economic stability, and to pursuing our strategic goals around the world."(Christopher 1996)

The Defense Department also is actively engaged in promoting the environment as an element of U.S. security, as evidenced by Secretary Perry's "preventive defense" policy. As articulated by Secretary Perry, preventive defense means enhancing "the conditions which support peace, making war less likely and deterrence unnecessary." And further from Secretary Perry: "By sharing what we have learned with other militaries and civilian environmental authorities, we can invest in the kind of defense activities that help to create the conditions for lasting peace. A healthy environment is a seminal part of the picture, as environmental protection supports quality of life and economic growth all over the world." (Perry 1996)

As we move into the transition to a new team of leaders in the second Clinton administration, we hope to build an even greater awareness of, and *response* to environmental security.

The federal role in addressing environmental security

One of the advantages we hold over previous generations is our advanced capability to predict, understand, and, in many cases, address environmental conditions through science and technology. Scientific and technological advances, along with our accumulated experience in dealing with environmental problems, give us many of the tools to "fix" current problems and prevent future troubles.

If we do not act now, however, we may lose the opportunity to play a pivotal role in influencing the decisions being made by developing countries. The *Economist* magazine recently forecast that in the year 2020:

- Nine of the 15 largest economies on the planet will be what we now call "developing countries."
- Developing countries will represent 62% of the global gross national product GNP.
- Indonesia will replace France as the fifth largest economy in the world.
- India will replace Germany as the fourth largest economy in the world.
- China may well replace the United States as the largest economy on the globe.

If we want to maximize the effect of our leadership in creating positive environmental conditions for the future, we need to act now on a continuum of environmental security issues.

<u>Solving problems.</u> The United States should act internationally to solve critical near-term problems that require immediate attention to prevent potential crises. Take,

for example, the unsafe operation of nuclear facilities and handling of nuclear materials. Left unaddressed, these problems could cause significant loss of life, long-term radioactive contamination, and even armed conflict in the near future. The United States has the experience and technical capability to aid countries in addressing these very critical problems.

Building capacity. The United States should help other countries develop their own tools and capabilities—both political and technical—to *prevent future stresses in their environment.* While the immediate environmental threats may capture the headlines, the more challenging and strategic job is to work to prevent what we expect to be the serious problems of the future: for example, the rising demand for natural resources, increasing waste output, and the prospect of global climate change are all exacerbated by exploding populations and subsequent increased consumption.

These challenges will not be met by "parachuting" technologies into a situation. The quick fix won't work. As in the old "teach a man to fish" parable, we need to work toward longer term and lasting solutions. Political commitment, social awareness, and acceptance, *and* technical infrastructure *in* the countries and regions affected are necessary elements if we are to be successful. We must approach the host governments and other organizations in developing countries as our partners in working for a better future.

Providing direction. As we all know, the industrial, economic, and political development of rapidly growing countries could go a number of different directions. In most cases, the path of least resistance for development for the near-term carries the greatest environmental cost for the future. Again, U.S. leadership is crucial. Environmental values should be clear in our aid and assistance policies and in our engagement at all levels with foreign countries.

One example of solidarity for the administration's position on the important connection between the environment and U.S. security interests is the agreement to cooperate on international environmental security projects signed last July 3 by the Department of Energy, the Department of Defense, and the Environmental Protection Agency. This "memorandum of understanding," or MOU was signed by Energy Secretary Hazel O'Leary, Defense Secretary William Perry, and EPA Administrator Carole Ann Browner, thereby highlighting the importance of environmental security at the highest levels of the U.S. government. (Department of Defense 1996)

DOE Secretary O'Leary said of the agreement:

> Clean energy and environmentally friendly technologies are among the keys to ensuring a safer, more secure future. By pooling resources we can make a greater contribution to environmental quality, economic growth, and sustainable development.

EPA Administrator Browner added:

> The agreement recognizes that protection of public health and the environment have become an important part of our national security. Environmental protection and economic growth go hand in hand, and both are essential to U.S. long-range interests.

And DoD Secretary Perry concluded:

> There is enormous benefit to having a strong working relationship among DoD, DOE, and EPA. Collaboration among these agencies demonstrates to other governments how the civilian and military sides of government can work together and how our different objectives can be compatibly met.

The practical purpose of the MOU is to provide a framework for joint interagency environmental security activities abroad. Reduced environmental stresses, improved conditions for regional and national stability, and partnerships with organizations in the host countries are the primary goals.

In addition to DOE, DoD, and EPA, close coordination with the State Department is ongoing; other federal agencies are expected to participate in the future.

Projects will include both military and civilian work to build in-country capability, including scientific research and development, technology diffusion, regulatory reform, training, and environmental management.

To this collaboration the Department of Energy brings scientific and technical experience in both the national security and environmental areas. The Defense Department brings a comprehensive network of military contacts around the world as well as tremendous experience with military base cleanup. The Environmental Protection Agency has expertise in the development of both regional and national environmental action plans with civilian authorities in the affected regions.

It is important to note that all three of our agencies are independently involved in numerous international projects right now. The point of the MOU is not to add another layer of bureaucracy to international projects, nor to replace all our efforts as individual agencies with joint projects. Rather, the point of the MOU is to identify those cases where our complimentary abilities and resources enhance our individual agencies' capabilities.

A primary example of such synergistic work is the Arctic Military Environmental Cooperation (AMEC), which is based on an official agreement between the United States, Norway, and Russia. AMEC focuses on military-to-military cooperation related to Russian navy nuclear spent fuel and associated facilities in the Arctic. Projects under the AMEC are designed to address the safe storage and transport of nuclear spent fuel, the treatment of low- and high-level radioactive waste; remediation for contaminated sites, and training for personnel involved in handling radioactive materials.

Although the Defense Department has the lead for the United States, DOE and EPA have been integrally involved in shaping the projects that are planned under the trilateral agreement. The implementation of these projects will also be a joint effort. Neither DoD, DOE, nor EPA has the mandate, resources, contacts, or technical expertise to handle these projects alone. Working together, we can accomplish important tasks that would be beyond the reach of any one agency working independently.

Adding value to the U.S. environmental security role

Given that environmental security represents the intersection of environmental and security issues, DOE is poised to be a major contributor on this issue. The history of the department is one of parallel investments in both national security, energy, and environmental capabilities.

The "glue" that holds the department together is science and technology. National security research and development has produced the nuclear science needed for nuclear deterrence. In conventional energy and environmental technology, our research investments have led to breakthroughs and advancements that have increased efficiency, decreased pollution, and greatly improved remediation practices. In addition, the DOE is the U.S. source of high energy, nuclear, and fusion physics experiments, and is a strong contributor to advances in bioscience. Our laboratory system has a proud history of scientific achievements in a wide array of disciplines unmatched in the world.

Examples of specific capabilities that may relate directly to international environmental security projects include the laboratories':

- Experience in developing and training personnel on emergency response procedures
- Experience in the safe handling of nuclear materials and the decommissioning of nuclear facilities
- Technologies for the safe transport and storage of radioactive waste
- Technologies for the remediation of radioactive and other hazardous wastes
- Assessment, characterization, and monitoring skills
- Technologies to upgrade or replace conventional energy production and use
- Ability to process and manage large volumes of data

No other agency has the dual perspective of basic science and engineering, or the variety of scientific and technical resources that exists at the Department of Energy. Environmental security is well within the scope of our mission and multidisciplinary capabilities.

How we should proceed

A working group has been formed to communicate and consult on the department's own, internal environmental security initiative. We have produced a framework document that outlines the goals, criteria, and priorities for international engagement, and we are developing an inventory of capabilities and ongoing projects abroad. This framework is consistent with U.S. foreign policy and serves our commitments previously outlined as critical elements of the U.S. role on environmental security—namely, solving problems, building capacity, and providing leadership.

The department's goals as stated in the framework are as follows:

- To establish environmental security as a major element of international program efforts
- To serve U.S. national interests through cooperative efforts to prevent or reverse global environmental degradation
- To encourage and assist foreign partners in the establishment of policies and commitments to mitigate and prevent negative environmental conditions

The framework criteria, which will serve as a filter to identify those projects that fit under our environmental security initiative, are:

- Failure to address the existing environmental conditions is likely to result in economic and political instability, life-threatening health effects, and/or possible international conflict
- Existing or potentially threatening environmental conditions may be positively addressed using available expertise and proven technology
- Private sector and local support for long-term solutions may be more forthcoming as a result of project partnerships.
- The United States has significant and ongoing interests in the region

Our priorities for engagement will be driven by:

- The linkage of international partnerships to "projects-in-place"
- The willingness of government and private sector organizations in the affected region to lead and/or participate
- The potential for accomplishing specific goals and objectives associated with environmental conditions
- The potential for positive and significant impact on the political and economic infrastructure of a country or region

In addition to the framework for decision making, we have also identified four broad categories of response which integrate DOE capabilities and interests. These are:

Analysis, research and testing: This category refers to the application of scientific methods to determine the nature and relative impacts of environmental conditions. More specific activities may include:

- Global, regional, and site-specific modeling
- Site characterization
- Emissions estimates
- Dosimetry studies
- Joint research and testing

Hazardous/radioactive waste remediation: This category refers to the application of scientific and technical methods to clean up or reverse the environmental consequences of pollution—including the radioactive pollution that reflects the legacy of the Cold War. Specific activities include:

- Hazardous waste handling, transport, and disposition
- Bioremediation and other cleanup techniques

Nuclear safety: This category of response encompasses the application of scientific and operational methods to improve the safety of existing nuclear facilities and the handling of nuclear materials. Again, specific examples are:

- Development of rational standards for categorization and operation
- Decommissioning and decontamination of facilities
- Safe handling of nuclear materials

Infrastructure development: This is a very broad category that refers to the application of scientific, technical and operational expertise to the development of capabilities for the production, distribution and use of energy and water, and the efficient use of natural resources. Activities in this category may include:

- Power generation, both baseload and supplemental
- Technologies for the efficient distribution and use of energy

- Water treatment and watershed management
- Wastewater treatment
- Development of environmental standards, laws, and regulations.

These activities draw from the capabilities of every DOE research, development, and operational program.

The next steps

Perhaps the most important step we can take is to lead by example. We are working to develop "Joint Action Plans" under the interagency MOU for activities in the Baltics and Poland. We hope to have projects up and running in these areas in the next six months. We expect these projects to focus on demonstrating U.S. technologies and training of local government and industry personnel to handle local and regional concerns.

The Gore-Kuchma Commission offers opportunities to address environmental security issues in the Ukraine. We will, of course, continue our important cooperation in Russia. Moreover, within the next year, I believe we will move on to some of the challenges presented in Latin America and Asia.

Our ability to successfully lead international projects depends on continuing support at home. In Washington, we will be working with the Administration and congressional leaders to raise awareness on the important issues encompassed by environmental security. Together, we can forge a vision for action that serves U.S. foreign policy, national security policy, science and technology policy, and economic policy interests while making the environment cleaner. If we are successful, we will also serve the global community by contributing to the conditions necessary for peace and prosperity.

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Perspective: Central Intelligence Agency

Ruth A. David

Buckminster Fuller once lamented: "The most important fact about Spaceship Earth [is that] an instruction book didn't come with it." I am happy to report that the national intelligence capabilities of the United States can help in putting together the instruction book. It's important to remember that intelligence is not simply information. Every scientist, researcher, or analyst knows well that mere information doesn't necessarily help you solve a problem. Usually we're swimming in information. What you need, of course, is the right information, made available at the right time—that's *intelligence*.

U.S. intelligence resources can bring much to the table—particularly our national overhead reconnaissance capabilities. Because of their superior performance during the Cold War, satellite and aerial reconnaissance systems are especially well suited to provide what we are now calling environmental intelligence. The story is now being told about reconnaissance from airframes such as the U-2, the SR-71, and the various satellite programs during the Cold War. In fact, the Discovery Channel recently carried programs on the U-2 and SR-71 spyplanes. CIA's Center for the Study of Intelligence has also published a well-received history of CORONA, America's first satellite reconnaissance program. It's important that this history is emerging so the public can understand why these systems are important to national security and why we need to continue to invest in them.

It is clear why this is so. Similar systems that helped keep the peace during the Cold War by giving our leaders a clear picture of Soviet strategic power remain in service to help preserve post-Cold War national interests. Our overhead capabilities help our customers understand and respond to humanitarian crises, military developments, and potential flashpoints—such as the Taiwan Strait crisis earlier this year, or a territorial dispute in the Aegean that could have escalated to war, or the unstable situation on the Korean peninsula. Imagery helps our leaders monitor compliance with arms control treaties. It helps them gauge the success of economic sanctions against rogue nations. And it provides our joint military commanders critical near-real time intelligence to support and assess military operations.

Let me focus briefly on a specific post–Cold War challenge that illustrates how well-suited intelligence resources are for assessing the environment. You already know about the international drug trade that threatens our cities, our families, the fabric of our society. As you might expect, the intelligence community uses aerial reconnaissance to give law enforcement authorities the leads they need to identify the infrastructure of the drug trade. We can, for example, locate laboratories, storage facilities, and remote airfields used by traffickers.

What you might not know—because it's been secret until recently—is that we can use satellites to monitor vegetation almost as well as we can find armored personnel carriers. We've long used satellite imagery to estimate crop size in North Korea, for example, so that CIA can forecast shortages that will require food imports or that could lead to societal instability.

In fighting the drug trade, overhead imagery allows us to estimate the extent of narcotics cultivation and production in the major drug-producing countries worldwide.

In fact, CIA's imagery-based estimates of coca and opium crops are the most reliable way to predict cocaine and heroin production. U.S. policymakers and law enforcement officials depend on those estimates to gauge the size of the global narcotics threat so that they can map out and fine tune our national counternarcotics strategy and plan interdiction operations accordingly.

We know from our 1995 imagery-based estimates, for example, that despite aggressive crop eradication programs in Bolivia and Colombia, Andean coca production reached a record high last year. After making the necessary conversions from hectares of coca to production of coca leaves to the final product—the cocaine that hits our streets—the CIA estimated 1995 global cocaine production at about 800 metric tons. That *intelligence*—information from overhead imagery plus our expert analysis—is an enormously helpful tool for our policymakers to get a handle on this problem. And it's a big problem, because global interdiction efforts seized only 250 of that 800 (metric) tons of cocaine, leaving more than enough to satisfy our country's annual demand of 300 (metric) tons.

Last month, General Barry McCaffrey, who runs the White House Office of Drug Control Policy, cited CIA estimates, derived from imagery, on global opium production—which has doubled since 1988 and in excess of about 4000 metric tons a year. Four hundred thousand tons of opium will make almost 400 metric tons of heroin; and the annual heroin demand in the United States is about 10 metric tons. I wish the news was better, but intelligence is very often the bearer of bad news.

The good news is that we have the tools to help our country confront the challenges of the post-Cold War world. National reconnaissance systems, which unlocked some of the most important mysteries of the Cold War (What is Soviet bomber production? How many ICBMs does Moscow have?), can help us fathom Nature. Leonardo Da Vinci observed that "Nature never breaks her own law," but the challenge remains for us to find out what those laws are.

We are already seeing a trend towards the more frequent use of these systems to support U.S. environmental initiatives, research, and policy. As a result of an initiative by Vice President Gore, the MEDEA (Measurements of Earth Data for Environmental Analysis) team was formed in 1994. This group of about 70 scientists from academia, the private sector, and government advises the intelligence community on the use of national intelligence resources for the study of the environment. MEDEA is also responsible for organizing and making available data from all these systems—satellites, aerial reconnaissance, observations from U.S. Navy ships, and other sensors—that can reveal important and *unique* scientific information on a variety of environmental concerns, such as

- deforestation,
- changes in the temperature of the oceans,
- wetlands management,
- and radioactive contamination.

MEDEA recently cooperated with Russian scientists to produce a digitized oceanographic atlas of the Arctic Ocean region—the most comprehensive study ever done. This atlas, scheduled for release in February (1997), doubles the knowledge of the Arctic available in the public domain. It will be followed by similar atlases on Arctic meteorology and the ice pack. Eventually, this intelligence may help scientists understand how the Arctic region affects and interacts with global weather patterns. Indeed, within hours after the 1986 nuclear disaster at Chernobyl in Ukraine, radioisotopes were detected in the Canadian Arctic. We need to know more about how that was possible. Another Arctic mystery concerns the fate of pollutants—including radioactive wastes dumped into Russian rivers during the Soviet era—that make their way into the Arctic Ocean. How will they affect U.S. and Canadian waters?

The Earth itself will show us the answers to the mysteries of our environment. As the prophet Job said centuries ago, "Speak to the Earth, and it will teach you." And U.S. intelligence resources can help unlock those secrets. One area where the Earth can teach us is the northern Sahara. MEDEA hopes that a historical analysis of satellite imagery of the movement of desert versus vegetation could shed light on how Atlantic hurricanes are born.

The leader of the Suquamish nation, the great Chief Seattle, spoke of this "interconnectedness" in the global environment when he said, "This we know: all things are connected like the blood which unites one family. All things are connected. Whatever befalls the earth, befalls the sons of the earth. Man did not weave the web of life; he is merely a strand in it. Whatever he does to the web, he does to himself."

The value of research conducted by MEDEA—and the unique role of national intelligence resources in understanding our changing global environment—is obvious. It's also clear that the benefits of this research belong to future generations—which makes it all the more imperative that we press on. The great French Marshall Lyautey once asked his gardener to plant a particular tree. The gardener objected that this tree was slow-growing and would not give shade for a hundred years. The Marshall replied, "In that case, there is no time to lose; plant it this afternoon."

We *don't* have to wait until the next century to see some real paybacks on the use of intelligence for environmental purposes. The intelligence community now routinely works with FEMA (the Federal Emergency Management Agency), the U.S. Geological Survey, and Department of Defense military commands, to help them in disaster response and monitoring. The same sort of overhead imagery that can detect ICBM launches or tanks hidden in the forest, for example, can help these agencies assess the conditions of roads and runways for relief efforts, monitor the extent of damage, or report on secondary threats from dams or nuclear facilities that may have been damaged, particularly after an earthquake.

This past summer, CIA's National Photographic Interpretation Center assisted the National Interagency Fire Center with imagery data that helped firefighters combat wildfires in Alaska, California, Idaho, Montana, and Oregon. This information on fire zones and perimeters was a vital substitute for data ordinarily collected by civilian aircraft, which had become scarce with the large number of fires out West.

Last year, local officials in the West Indies were alerted that imagery data pointed to the imminent threat of a volcanic eruption on the island of Montserrat. Four thousand people were evacuated until the danger passed. More recently—in fact, last week—we observed that a section of the crater looks like it may collapse, with possible catastrophic results for several villages south of the volcano. Again, residents have been warned of the danger.

We recently helped the Department of Energy save time and money in locating waste disposal sites from the 1950s at the Oak Ridge nuclear facility. We also are helping the Navajo Nation with technology and training to exploit Landsat multispectral satellite imagery of its region in the Southwest United States. This is an exciting partnership with the young people of the Navajo, to involve them in scientific efforts to understand and better manage their natural resources and environment.

There are many other reasons to expect that we will increasingly use our intelligence capabilities with an eye on the environment. Environmental developments affect economies, populations, governments, our own military planning, and our diplomatic efforts. In fact, one of MEDEA's responsibilities is to advise the intelligence community on how the environment affects these more traditional intelligence issues.

Last month, a member of the Federation of American Scientists wrote the following in *Aviation Week and Space Technology*: "The best thing that the U.S. intelligence community could do for America, and itself, would be to recognize the public as a customer for its products." I can tell you that we are there already.

Last July, CIA Director John Deutch declared in a speech to the World Affairs Council in Los Angeles, "The environment is an important part of the intelligence community agenda. . . our job is to acquire the data and allow the scientific community to use them. . . the costs are small and the potential benefits enormous."

During the Cold War, the public benefited enormously from national intelligence resources. Peace was the dividend, and the public continues to benefit as these systems serve our national interests—not only keeping the peace, but keeping and preserving the environment.

Sixty-five years ago, Albert Einstein advised the students and faculty of the California Institute of Technology that: "Concern for man himself and his fate must always be the chief interest of all technical endeavors. . . in order that the creations of our mind shall be a blessing and not a curse to mankind. Never forget this in the midst of your diagrams and equations."

The men and women of CIA and the U.S. intelligence community are excited at their role in bringing about the wisdom of Einstein's words, that the fruits of their labors will be a blessing on mankind and the global environment.

Building international environmental alliances

Joanne M. Kauffman
David H. Marks

The history of the Massachusetts Institute of Technology is linked very closely with both the development of technologies for national security and with industrial development in the United States. Through our partnerships with government and industry we have found the coexistence of fundamental scientific research with advanced technological research to be very effective in working toward innovative solutions to a wide range of national defense, economic, and social issues. Today, *global* environmental issues are very much in the forefront of our educational and research agenda. Because the issues are global, we recognize the need to work with other universities with complimentary strengths—and similar relationships with industry and government—to fulfill our educational and research mission in this new realm. Hence, the creation of the Alliance for Global Sustainability. This partnership of three technical research universities worldwide—MIT, the Swiss Federal Institutes of Technology, and the University of Tokyo—was established to develop new and innovative policies, industrial processes, and technologies that are needed to ensure a sustainable and secure global future.

Sustainability, national security, and the need for cooperation

Although terms like "sustainable development" and "sustainability" have gained currency ever since publication of the now famous Bruntland Commission report "Our Common Future" in the early 1980s, many people are uneasy using them. What, they ask, do these vague and indefinite terms mean to human development and progress? What are the benchmarks? How do we know we are meeting them—whether we are in business, industry, government—or, for that matter, as individuals in our choices of daily living? I am not foolish enough to attempt a definition here. It would be impossible for our purposes to try to condense the voluminous work that has been carried out to define and operationalize these terms. However, it is clear that they embrace two concepts that are also fundamental to the provision of security: futurity and equity. Sustainability is primarily an issue of intergenerational equity. As the framers of the Bruntland Commission put it, sustainability means that consumption and development of the present generation should not come at the expense of development of future generations (World Commission on Environment and Development 1987). This is not to say that sustainability issues are relevant only to the distant and unforeseeable future. Were this the case, one might be tempted to take the technological optimist's view that market demands will eventually result in the development of the technologies needed to correct negative effects of older ways of doing business. In fact, the situation is more urgent than that. The notions of futurity and equity also apply to immediate concerns about disproportionate development within highly industrialized countries and, clearly, between developed and developing economies.

To my mind, widespread use of the terms "sustainable development" and “sustainability”—and many international attempts to define them—reflects growing global concerns about modern patterns of industrial and economic development, and unease about ensuing environmental decline and persistent economic inequities. In a world of limited capital resources, burgeoning populations, and increasingly intense energy consumption, demands for rapid development pose formidable immediate challenges to all institutions in developed and developing countries alike. In a world of burgeoning populations where basic human needs cannot be met, the notion of security is closely linked to the concepts of futurity (development) and equity.

The world’s population today is nearly six billion people. It is expected to reach eight billion before the middle of the next century, and perhaps double by the end of the next century. Yes, governments could act to stabilize population at lower levels, but as others have pointed out (MacNeill et.al. 1991), with one-third of the world’s people under 15 years of age, even the most vigorous policies will not avert rapid population growth and the accompanying need for large increases in the provision of energy, transportation systems, and improved communication technologies. How to meet those demands without compromising resource availability, human health, and ecological balance is the challenge of sustainability. Failure to do so will clearly threaten security at many levels: local, national, regional, and global.

Let us briefly consider some of the evidence:

Rising numbers of people will increase global demand for food, fresh water, and shelter. But today, a combination of pollution, over-harvesting, and inefficient uses of technologies are threatening the sustainable yield in ocean fisheries, the amount of fresh water produced by the hydrological cycle, and the amount of arable land for sustainable agriculture. By the year 2000—no longer the distant future— nearly two billion people will not have access to safe drinking water. And although global food production has increased in the last 50 years, massive soil degradation and loss of top soil around the world is cause for increasing concern about the world’s ability to meet basic nutritional needs. The global impacts of the regional problems are not difficult to anticipate. Environmental calamities in China, India, Africa, and Eastern Europe will resonate economically and socially throughout the world.

Beyond the regional scale environmental threats are those that compromise the global commons. For the first time in history, the integrity of the atmosphere is threatened by human activity. For many years, scientists have been issuing warnings about the impacts of industrial activity on the atmosphere—and the potential ensuing effects on the global environment and human health. Today, international negotiations at virtually the global scale are under way to address threats to the global commons.

The causes of global environmental problems—pollutants emitted as a result of worldwide modes of energy use, transportation, industry, farming, and forestry—are embedded in industrial and agricultural practices. These practices lie at the core of the highly competitive economies and lifestyles of the industrialized world and, increasingly, the developing world (Sebenius 1989). Competitive use of global resources to support these economies is the dilemma of the commons on a planetary scale. Environmental threats to the global commons share several characteristics that pose unique challenges to the political process. The shared characteristics that render these problems particularly thorny in the political context (and, hence relevant to security issues) and difficult to deal with are:

- The issues involve difficult tradeoffs between current economic or social benefits and uncertain adverse effects
- The issues are characterized by economic and scientific uncertainty
- The implications of this uncertainty are most pronounced with respect to potential effects
- The effects, if manifest, may be global
- The effects of long-term environmental threats are cumulative. They depend not just on what is happening now, but on the history of industrial and consumer activities

Briefly stated, global environmental challenges are complex, they lie at the intersection of economic and environmental goals, they transcend national borders, and no single country can address them alone. Moreover no institution whether industrial, public, or academic can provide complete solutions. Yet the strength of each can be enhanced by working together. In this context, the modern research university must play a major role.

The role of the research university

The role of the modern research university is rooted in three characteristics: a commitment to intellectual objectivity; an emphasis on the discovery and development of new scientific knowledge and new technologies; and a dedication to educating the next generation of scientists, engineers, and decision makers in society, industry, and government. It is through these characteristics that the university can make a contribution to overcoming environmental threats to security. Dealing with the difficult tradeoffs that will be needed to address global environmental threats will require the provision of neutral forums where stakeholders in the issue can meet and attempt to come to greater understanding. As objective analysts of global environmental problems and their consequences, universities are uniquely placed to fulfill the role of providing such forums.

We also play a major role in educating future decision makers to tackle these emerging and highly complex issues. Our central mission and primary responsibility is teaching. As MIT President Charles Vest emphasizes, “We must educate our students to understand both the importance and the complexity of environmental issues. Beyond that, we must provide them with the technical understanding, political awareness, and managerial acumen needed to deal with these issues in substantive ways. Sustainability is not a job for environmental experts or corporate health and safety officers alone. It is a consciousness that all leaders, designers, planners, and workers must bring to their work.” (Vest 1996)

The foundation of intellectual objectivity is high quality scientific experimentation and thorough analysis. Understanding of global environmental threats and their potential consequences to security writ large will require two kinds of research—what Harvey Brooks (1982) has called “defensive” and “offensive.” Defensive research is aimed at anticipating possible adverse effects of technology before they become manifest. Offensive research is designed to develop the basis of new products or services to meet new human needs or old needs better. The former depends on long-term fundamental research that has as its primary goal the generation of knowledge. In the context of global environmental issues, expertise for knowledge building within and across many different fields will be necessary from the natural sciences, engineering, and social sciences. This is where our greatest contribution to global sustainability may be made. Our research challenge is to foster interaction among the diverse disciplinary fields needed to develop the scientific and technological base, to facilitate the policy discourse needed to understand the issues, and ultimately to solve the problems before us. Defensive research, on the other hand, requires the intimate knowledge of markets and competition that resides in industry. From this it is clear that the contributions that research universities can make to global sustainability—no matter how important—cannot be achieved in isolation. We cannot define by ourselves the research agenda nor build the educational and research resources needed to address these complex problems. In order to be effective we need to cooperate with industry, government, and other academic institutions—and we need to do this on a global basis.

In sum, the role of the university in sustainability can be summarized in four points:

- Educating professionals
- Enhancing multidisciplinary approaches to problem solving and ensuring environmental literacy across disciplines
- Working with industry and other stakeholder partners to set the research agenda, and to ensure the highest quality scientific experimentation and thorough analysis
- Applying the commitment to intellectual objectivity

Activism in this context means taking the university a step beyond its normal role, to working with industry and other stakeholder partners to set the research agenda to search for new solutions to complex environmental threats; to ensure that the knowledge we generate is accessible to decision and policymakers in all sectors; to provide an objective platform for discussion of complex issues; and, when possible, to facilitate negotiations on the difficult tradeoffs that are inherent in dealing with complex sustainability issues that lie at the intersection of economic and environmental goals.

MIT's international environmental alliances

At MIT we have many programs that are built on partnerships with government, industry, and other academic institutions. In the environmental area they include such activities as the Center for Global Change Science, the Joint Program on Global Change, the Program on Environmental Engineering Education and Research, the Sea Grant Program, the Parsons Hydrology Laboratory, the Center for Environmental Health Sciences. What is becoming increasingly evident, however, is the need to go a step further.

While the history of MIT is linked with industrial development in the United States and throughout the world, we must increasingly look toward active involvement in global technologic development and increasingly work with international partners in academia, government, and industry. We are pursuing a number of avenues to share our experiences in cooperating with industry to address complex technological and social problems—such as those that environmental threats represent—worldwide. At the same time, in building these alliances, we learn from the knowledge base of their academic and industry communities about the regional and even global impacts on, and effects of, local environmental conditions, and industrial and social activity. For example, we are working with government, industry, and academic partners in several countries, such as Thailand, Malaysia, and Brazil to develop human resource capability within their academic and research institutions and to increase institutional capacity for transferring knowledge from these institutions to their industrial communities. These programs have a strong environmental component, which is essential to building modern technological capability within these countries themselves—and in particular to strengthening the local human resource base to deal with complex sustainability issues in development. In China, with our partners from Switzerland and Japan, we are working side-by-side with experts from Chinese universities, local communities, and government on the complex issues of the use of coal in China—especially in the small industrial and household sectors where the results of our research, combined with an education and training program, are likely to have a significant near-term effect.

The creation of these alliances in recent years suggests a new outward looking role of research universities. The trend reflects awareness that universities, like industry, simply cannot remain viable without an international focus. We are learning rapidly what it means to be part of a global system—that we really are all in this together. As one of my colleagues put it, "You can't sink half a boat—one end just doesn't go down without the other."

The Alliance for Global Sustainability

Knowledge of this led MIT to be part of the creation of the Alliance for Global Sustainability—partnership that allows the partner research universities to work together with representatives from industry and government worldwide to address issues of sustainability. The AGS captures MIT's interdisciplinary activity and focuses it on global environmental issues in partnership with universities in Europe, Asia, and Latin America, and with corporations and government representatives throughout the world. All of MIT's environmental, education, and research programs participate in it.

The AGS was created in 1994 specifically as an international forum to capture the results of research at our universities, supported by sponsoring companies, and to put these results to use in policy and regulatory formulation, in corporate planning, and in design and engineering. We see it as taking a step beyond the traditional role of universities to a more activist role.

Interdisciplinary and multigeographic research consortia are being built under the aegis of the AGS to develop new processes and technologies that are urgently needed to meet growing worldwide demand for energy, mobility, communication, habitat, and other essential building blocks of modern societies. Our targets are pathways to sustainability that we believe will emerge only from complex systems approaches to solving sustainability problems. But our goal is not only to generate knowledge, but to ensure that this knowledge is accessible for decision making at all levels—personal, private, and public. Thus, an important aim is to link groups that have the most power to mount an effective agenda. These are practitioners from industries that are already dealing with remediation, minimization, and prevention of environmental threats; government decision makers; representatives of environmental and social welfare activist groups who are in a position to influence policies throughout the world;

and researchers in academia who can convene contrasting points of view and apply rigorous peer review and independent verification of various proposed processes, policies, and technological solutions.

Drawing on the strengths of the partner institutions, the AGS is developing an ambitious agenda that is focusing on nine critical "pathways" to global sustainability. We now have research consortia developing agendas on global climate change which build synergistic strength from individual modeling efforts at each of the universities; on energy choices for the 21st century with a focus on "existing in a greenhouse constrained world"; on transportation and social mobility; the cumulative social and economic problems of the world's burgeoning megacities; the assurance of the availability of water and food in arid and semiarid regions of the world; the development of new greener technologies to meet development demands without compromising the future availability of natural resources, human health, and ecology; and on the development of policies that will enhance and facilitate sustainable practices in industry, through trade, and in personal choice. The AGS is also building a consortia on China in which all of these areas have particular significance not only for the integrity of China's environment and development, but with potential impacts throughout the world.

As the original title of this paper proposed by my colleague and leader of MIT's environmental initiatives, Professor David Marks, indicated when he called it "herding cats," the creation of the Alliance has not been easy. We face enormous challenges in working across great distances, different cultures, and with different partners in industry and government. But we are moving forward. The third annual meeting of the AGS at MIT in January 1997 includes the first meeting of our International Advisory Board and decisions on distribution of the first round of funding specifically for building the international AGS research consortia on the pathways to sustainability indicated above. We are encouraged by the external interest and support that the AGS has begun to garner—and we are already beginning to see the results of the international collaboration that the establishment of the AGS engendered. For example, our green design team is completing a text on comparative green design that will include chapters on international comparisons and policy perspectives: i.e. what policies may foster or hinder steps toward green design and innovation.

The AGS is a work in progress and, I believe, a harbinger of things to come: an academy that is more outward looking, more cooperative, and because of that, better equipped to educate students to meet the real challenges in industry and government of a rapidly changing, interdependent world.

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Part three:
Global dimensions

Earth stewardship

Peter M. Eisenberger

The idea of Earth Stewardship has many origins but it was perhaps most dramatically imprinted on our consciousness as we witnessed the images of our planet as it was viewed from the Moon in 1969. Starting with Earth Day in 1970 in the United States and similar activities in other developed countries, increasing attention both politically and scholarly, has been paid to the nature of human impact on our planet. Politically, a new broad consensus—one that declares we need to be concerned about human impact on the environment—appears to have emerged in the developed countries. While there is consensus on the need to moderate our impact, significant disagreements exist about how much wealth-generation activities and other human endeavors need to be reoriented to protect the environment. Furthermore, tensions have emerged between the developed and underdeveloped countries as to who should pay and who should operate under the greatest constraints. These can be viewed as the first of many difficult choices we will need to make to achieve wise stewardship of our planet. Failure to make those choices wisely will create various threats to U.S. and global security.

Scientific studies have revealed distinctive signs that human activities are having impacts on a global scale. The ozone hole, signs of global warming, species extinctions, and pollution of our water, land, and air have been connected to human actions. Furthermore, the earth sciences have continued to enhance our understanding of the large natural changes in environment and species that occur even without human impacts. We now clearly recognize that the Earth's interior, surface, and atmosphere are a dynamic web of interconnected systems that have been and will continue to be subject to changes that produce significant consequences for humans. Examples include major glacial periods, smaller regional climatic changes, large scale volcanic eruptions, earthquakes, and even possibly the impact of comets or meteors from space. Our ecological studies have revealed that the net impact of these natural variations on species that occupied our planet before us has been dramatic, to the point of causing periodic mass extinction (Raup 1988).

In spite of the broad consensus on the need to moderate human impact on the environment, there exists a polarization as to how we should proceed. The polarization is at all levels: internationally, between developed and underdeveloped countries; between corporations seeking to create wealth by providing products and services for our use and governments concerned about the environment; between the recreational interests of individuals and the environmental concerns of other individuals.

The stakes in choosing the right path and then providing wise stewardship for our planet are great. In purely economic terms, natural systems that provide the energy, water, air, and other resources we need would cost an enormous amount to provide, even if it were possible, through human technologies. (A recent workshop at the National Center for Ecological Analysis and Synthesis concluded that the value of natal services is comparable to the gross world product [Costanza et al., submitted to *Science* November 1996].) The dislocation effects of massive climate change on a short time scale are hard to estimate but are in all likelihood large. However, any reduction in worldwide wealth generation will cause increased poverty and human misery promoting social instability. It will also weaken our ability to invest in the future and thus obtain the knowledge and tools to become wise stewards. Deeper spiritual and ethical issues are also of concern, striking at the core of our identity and our relationship to the natural world. This has moved E.O. Wilson to suggest a policy of zero species extinctions as an ethical requirement for our policies.

In the course of debating how we should proceed, extreme views have dominated the discussion. Global warming possibilities have been translated into massive global changes, species extinctions have led to speculation of destabilizing the global ecosystem, and population growth has been viewed as a threat to the planet. On the other hand some contend that the Earth is much more robust and that human ingenuity will be powerful enough to cope with natural and anthropogenically induced changes. Proponents of this view point to the enormous progress made since the first Earth Day in 1970 (Ausebel 1996). Furthermore they argue that without a robust economy we will not have the wealth needed to provide for human needs and to protect the environment, not to mention potential social upheaval.

What is particularly noteworthy about this intense debate, in spite of the fact that considerable progress has been made, is that while most people ultimately invoke global arguments, nobody really knows how the Earth system will respond either to future natural or human disturbances at any other scale than the very local (e.g. the river will be polluted if you dump toxic substances into it). We are beginning to understand some regional issues (e.g. identification of key components of ecosystems), but at the global scale there is almost no understanding of the impact of human and nonhuman changes. Those that are predicting doom or those that are confident of our ability to cope are simply guessing because of our incomplete understanding of the complex linkages that exist between all the components of the Earth's system and the resulting response that those linkages will provide at a global level. It is much like arguing about the impact of a particular action on human health in the absence of an understanding of some important parts of the immune system and its response to a particular treatment.

One way to quantify our current lack of understanding and simultaneously define the need for enhanced research efforts is to list a set of questions whose answers we need to know in order to make wise decisions on how to proceed.

Carrying capacity

- How many people can our planet support and at what cost to the environment as a function of consumption patterns and technological capability (e.g., pollution reduction systems, technology)?

Risk assessment

- How can we make meaningful risk assessments in cases of low probability outcomes with great impact?

- How can we identify beforehand the possible health consequences to humans and the biosphere of particular wealth generation (technology) or lifestyle options?

- How can we determine the robustness of the Earth/human systems to both natural and human perturbations?

- How can we best monitor the health of the Earth and its inhabitants to get an early warning on possible adverse effects?

Predictability

- How can we maximize the societal and environmental benefit of our increasing ability to predict climate (e.g., agriculture, flood control, human and ecological health)? How can we more generally transform knowledge of how physical, ecological, and social systems function into effective outcomes?

Preparing for change

- How and where can we best develop human habitats to minimize damage from natural phenomena (e.g., floods, earthquakes, etc.) as well as minimize its negative impact on the environment?

- How can we design the structure and infrastructure of our economy and business world to promote the greatest wealth generated at the lowest cost to the environment?

- How can we best protect other species and ecosystems (especially those that perform no "useful" function)?

Education/learning

- How can we provide the education/learning needed for humankind to make informed decisions with respect to the many tradeoffs we will continue to face (e.g., wealth generated versus environmental health)?

These questions and many others cannot be answered by studying an individual part of the Earth or human subsystem. Therefore, we need to extend our current studies by pursuing a more integrated approach that involves consideration of many parts of the Earth/human system. In turn these studies can help provide the knowledge base for wise global planning, global mitigation and global engineering. Taken together they can provide the basis for wise stewardship of our planet.

In describing a research program to provide the needed knowledge base, it is clear that both natural and human actions taken in one region of the Earth can impact those in other regions and countries, even places very distant from the sources. A clear example is our growing understanding of the connection between what happens in the seas off South America and the climate in North America, the eastern rim countries of the Pacific, as well as sub-Saharan Africa. This means that new global mechanisms for deciding upon and implementing Earth Stewardship will be required. Due to a lack of expertise, these very important issues will not be addressed here in any detail. In general terms, there is the critical need to include the social and political sciences as part of the research agenda in order to help develop the new policies and infrastructure needed to support wise stewardship.

In addition, as our understanding of Earth systems evolves there will clearly be a need to incorporate that understanding into our educational system at all levels. We need citizens to participate in the process of making the difficult tradeoffs that will almost certainly be required. Professionals in all kinds of endeavors will need to be informed so that they can also make the appropriate tradeoffs. The required educational reform and efforts will not be described though they clearly are a challenge to which our schools, universities, and informal learning institutions must respond.

Finally the description of the proposed research agenda will be quite general. This is not only required because of the limited expertise of the author, but more importantly, because deciding exactly how to proceed will require a planning effort involving leaders from a broad spectrum of disciplines and perspectives. The main point of this paper is to emphasize the need for a total systems approach for wise stewardship. This paper will end by describing a possible process for determining the priorities for a national research agenda.

Proposed research agenda

The proposed research agenda has three related components and bears some loose analogy to what has evolved in the health sciences. The proposed program for a "healthy" Earth/human system has one component that can be regarded as the search for the DNA equivalent for understanding the basic mechanisms that organize the Earth/human systems. The second is equivalent to the human genome project through which one will try to understand the relationship of the various Earth system component (e.g. air, water, soil, species) or human systems (policy, economics, law, health, technology) to one another and their impact on the overall system performance. Finally, the third component will be the equivalent of disease specific and public health studies and will involve increasing our detailed understanding of the individual components of the Earth/human system and the processes and approaches that can mitigate our adverse impacts. These disciplinary based studies must continue to be strongly supported even as we begin our efforts to focus on understanding the systems aspects because they will serve as the testing ground for our understanding of the overall system.

Global system

What kind of system describes the way the Earth responds to perturbations and how will (can) our human system respond? Is the Earth/human system noise driven, an example of chaotic systems that have been used in meteorology, population biology and economics, and that are now being further considered by some physicists? Does the oscillating pattern in the history of our planet's climate and number of species represent some fundamental concept similar to Turing's explanation of pattern generation in biological systems (e.g. why do zebras have stripes?) (www.pmi.princeton.edu/faculty/ECC.html). Applied mathematics is increasingly interested in nonlinear modeling systems that have a series of low-probability outcomes with great impacts. Can such an analysis help us understand the Earth system or how to perform a more enlightened decision analysis or risk assessment? Alternatively, is the system simply complex without unifying concepts similar to the genetic code? If so, how far can we go with brute force modeling given the expected enormous increase in information processing and modeling that will emerge in the next ten years? Such modeling will involve very difficult temporal and spacial scale issues given the range of phenomena that need to be considered. Alternatively, if such brute force modeling is not possible, what simplifying approaches will enable us to capture the significant elements?

All candidates for an increased understanding of the total Earth system should be tested on the past history of the evolution of Earth systems wherever possible before being applied to future predictions. The systems studies and the information gathering activities on the changing Earth systems, such as conducted by the Earth Observing System (EOS) or data collected by the U.S. Geological Survey (USGS) need to be coordinated to ensure that the needed information is acquired.

Similar efforts need to be conducted within the social sciences to help develop more quantifiable models to describe the dynamics and responses of human systems to internally and externally driven changes. These should include such key topics as population studies, resource and information flows, economic and decision making systems. While for the lay public the reduction of human systems to quantitative analyses may be troubling, it is essential that we develop as quantitative an approach to human systems as possible to provide a common language for the physical and ecological investigators to converse with each other and with their social science colleagues in order to obtain a comprehensive understanding. There is a critical need for this discourse because the questions we need to answer span the traditional disciplines. This will be a very difficult challenge but we must begin to build the bridges in order to be able to effectively translate our increased understanding into effective social action. Our universities and colleges have a critical role to play in developing our ability to carry out the need discourse. Thus, one needs to augment the current disciplinary approach to education and research with courses and new infrastructure that will enable the needed multidisciplinary efforts to succeed. The gap that currently exists between the generators of scientific knowledge and technological innovations and those responsible for designing human systems (e.g. political, legal, economic) must be closed at all levels including research, education, and actual decision making.

From the above it is clear that a direct study of the overall global system will require a very broad range of disciplines and will be extremely challenging, so it must attract the best and brightest. Initially at least it does not need to be a large effort, but rather should promote a diversity of approaches. As progress is made, investments in the most promising aspects should be appropriately increased.

Systems linkages

Because of the great complexity involved, the attempt to directly understand the Earth/human system is a very difficult, some might even say impossible, task. Yet it is critical that we advance our understanding as quickly as possible to help us make the difficult choices that lie ahead. As is the case for many other complex challenges, one can make considerable progress by identifying the key factors that underlie the complexity. For example, our study of ecosystems has already identified various areas where certain "keystone" species are essential for the survival of the overall ecosystem. Therefore, in addition to the attempt described above to extract the basic nature of the total Earth/human system and discover a conceptual simplifying framework, is the need to enhance our understanding of the key linkages (strong coupling and resonances) that characterize the overall system.

As stated earlier, the questions we need to answer will depend upon our understanding of the important connections between the various parts of the Earth/human system. Here again there may be some value in drawing an analogy with the health sciences in that we know for humans that 90% of DNA appears to have no function. In a similar manner one might expect that there are some critical sites and phenomena in the overall Earth system that, if perturbed, could have serious impacts while others may not be important for the global system. An example of the former is the El Niño effect where it is recognized that what occurs at the atmosphere/ water interface off the west coast of South America can have a serious impact on larger scale Earth system behaviors. On the other hand, comparable sized spots on the Earth have experienced massive changes in their basic character with no perceived global impact. From a more fundamental level it is a general characteristic of nonlinear systems to have certain excitations that are resonant in the sense that under certain conditions their amplitudes become very large when either driven from external perturbation or in some cases simple system noise. In mathematical terms some perturbations will experience positive feedback and grow while others will be reduced by negative feedback.

Attempts to identify such resonances and feedback mechanisms in the physical/ ecological Earth system will clearly serve two purposes. The first goal, of course, should be to identify areas in which we need to be particularly careful with any human activity that could trigger a resonant excitation. Of course, these sensitive spots or actions can have serious negative consequences but also if completely understood could serve as control points to offset potential negative developments caused by other actions either by the other Earth system excitations or human activities. These could become candidates for Earth engineering projects in the future when we better understand the overall system.

The second benefit from such a study of course is that they inform our attempts to understand the complete system and they become prominent features that proposed conceptual frameworks will need to explain. To carry out such studies will require experts in each of the subsystems to work together to identify and understand such resonances and, of course, will require funded programs that can evaluate and support such multidisciplinary activities. Again, here a comparable analysis is appropriate for the human activities: economic, health, legal, and political (policy) systems. Namely there will be certain areas that can critically influence how the overall systems will respond to increased knowledge of the tradeoffs between wealth generation and quality of life considerations and the impact on the environment.

A specific example would be the issue of the best approach for achieving needed reduction in pollutants in our atmosphere. One would clearly need to establish and integrate policy, legal, economic, and health-related approaches to achieve the needed reduction in the impact of pollutants in a cost-effective manner. The market mechanisms and legal sanctions chosen have had, and will continue to have, a profound impact on the nature of economic activity that will result. This in turn will determine the cost-benefit ratio of a particular remediation approach. An example of this was the reduction of $S0_2$ in which a market mechanism was used instead of command and control to achieve the reduction at a much lower cost. The choice of one technological approach over another for achieving a reduction can also be very important. An example of this is that if the United States had decided to subsidize mass transportation rather than financing the highway program, which supported the automobile industry, the transportation system and its impact on the environment would be considerably different than it is today. In this context the new field of industrial ecology is likely to be of increasing importance in helping to analyze industrial and government practices from a systems perspective that explicitly includes evaluation of the environmental and revenue cost impacts of various choices.

Individual systems

The organization of the current research enterprise has resulted in a very high quality understanding of individual Earth systems in isolation. One way of classifying the disciplinary work which has taken us to our current state and also, of beginning to think about how to proceed next is illustrated in Figure 11-1. In the context of that figure the classical disciplines of chemistry, physics and geology have focused on physical systems; biology and the medical sciences have focused on life systems; and social sciences and engineering have been centered on human processes. By and large the physical and biological have been thought of as natural while the purely human has been considered unnatural, at least within the context of western philosophy.

As we move ahead to build the understanding needed to provide wise planetary stewardship, we must expand our endeavors to include problems that lie at the intersections of Figure 11-1. As a parallel endeavor, we must, as described above, also continue to support the excellent disciplinary work that has produced our current state of understanding and knowledge.

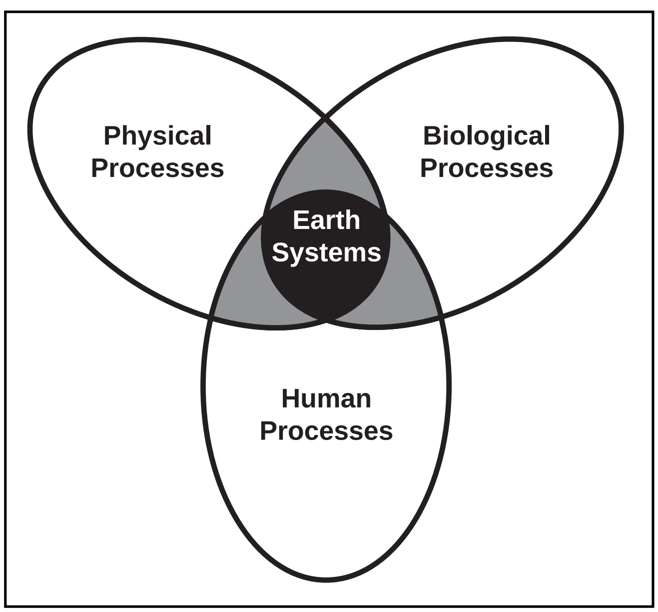

Figure 11-1. Classification scheme for disciplinary and interdisciplinary investigation of earth systems.

1. The physical system

—*Atmospheric gases.* By far the most prominent example of our understanding of the physical systems of our planet as they pertain to Earth Stewardship has to do with the chemical composition of the atmosphere and its relationship to the average temperature of the atmosphere. While there is still debate concerning the impact of changes in the chemical composition of the atmosphere, it is well established that in the history of our planet, changes related to glacial and interglacial periods have included significant changes in the concentration of CO_2 and other atmospheric gases. The relationship between the temperature distribution at Earth's surface and changes in the composition of the atmosphere is currently a rapidly advancing field. Since the first report by the Intergovernmental Panel on Climate Change in 1990, the scientific community has advanced from a statement that it would be on the order of a decade before confident statements could be made with regard to the anthropogenic signal in atmospherically driven changes in temperature, to the cautious statement of the second IPCC assessment released in 1996 that indicates a human signal is present in current changes in climate. That rapid change in confidence reflects dramatic advances in our understanding of the warming effects of greenhouse gases and the compensating cooling effects of atmospheric aerosols and in our ability to construct computer models of increasing spatial resolution that incorporate our rapidly advancing understanding of atmospheric chemistry and physics.

—*El Niño /Southern Oscillation.* El Niño is an oceanographic phenomenon in which the thermocline along the western coast of South America deepens and results in significant climatic variability throughout the eastern Pacific Rim. The Southern Oscillation is an episodic change in the large-scale atmospheric pressure of the southwestern Pacific region. The associated changes in pressure change the atmospheric circulation and also result in significant climatic variability.

Circulation of the atmosphere and of the ocean are both fluid dynamics problems albeit with dramatically different scaling considerations. In classical studies of these two systems, they were considered independently with the unstudied system serving only as a boundary condition for the system of interest. The realization that the El Niño and Southern Oscillation phenomena are fundamentally linked has led to dramatic advances in our understanding of seasonal-to-interannual climate variability. That work has been driven by focused study of the coupling between the atmosphere and ocean circulation systems and has opened the possibility of understanding of the atmosphere/ocean system as a whole. Our current understanding is such that we can predict sea-surface temperature in the central Pacific 12–18 months in advance with useful confidence (Cane et al. 1994). From that prediction we can also make statements with confidence concerning the climate in specific regions spanning the globe.

2. The life system

—*Historical biodiversity.* Over the roughly 4.5 billion years that Earth has supported life, there have been dramatic changes in the character and diversity of that life. Perhaps the most dramatic change in the character of life on Earth is also related to the most fundamental change in the composition of the atmosphere: the emergence of photosynthesizing organisms and the development of free oxygen in the atmosphere.

The fossil record that supports most of what we know about extinction and species origination is most reliable following the evolution of shelled organisms about 600 million years ago. These organisms emerged in a radiation that produced most of the major phyla and dramatically increased the number of species. Since that time species extinctions have been nearly as common as originations.

On occasion in the history of Earth there have been events in which the majority of the species extant have been extinguished. The largest of these occurred about 250 million years ago and removed about 52% of the families. Efforts to extrapolate that number to species yields extinctions on the order of 77% to 96%. The mass extinction at the end of the Cretaceous (~65 million years ago) is believed to have been caused by an asteroid impact. Even in this relatively recent event there is debate concerning the mechanisms of mass extinction. Current estimates of the number of species range an order of magnitude (~3–~30 million). The current state of understanding indicates that current extinction rates related to the destruction of habitats probably far exceeds the background rate.

The range of historical and current estimates and the lack of certainty concerning mechanism are symptoms of the great difficulty associated with making statements concerning the diversity of life on Earth. Much work remains to be done on such fundamental questions as the continuity versus episodicity of extinction and the role of extinction events in the long-term processes of evolution.

—*The diversity/stability debate.* Much of the ongoing debate concerning current biodiversity issues is centered on the relationship between the magnitude of biodiversity and the function and stability of ecosystems. In particular the working hypothesis is that greater biodiversity leads to greater stability in ecological systems. While there are studies that seem to demonstrate this principle for particular ecosystems (Tilman and Downing 1994), the mechanisms that would underlie such a relationship remain elusive. This is primarily due to the difficulty in doing controlled experiments in open systems with large numbers of free parameters.

At a recent meeting at the Biosphere 2 Center in Oracle, Arizona, a group of leading ecologists began to consider how facilities such as Biosphere 2 might address such complex issues as the relationship between diversity and stability. In particular, discussion of the role that large experimental facilities such as Biosphere 2 might play in isolating underlying mechanisms was begun.

3. The human system

—*Political economy.* If it has no other effect, the Rio conference clearly articulated the inextricable link between environment and development. Beyond the physical sciences, it may well be that economists have been the most vocal in their discussions of greenhouse warming and resource use issues. As noted above, the most vociferous debates concerning stewardship in the 21st century are those surrounding how we should act in the face of our growing understanding of the relationship between anthropogenic forcing and planetary function.

Economics seems to be the driving force of today's environmental destruction. Since World War II the world has used resources voraciously in the pursuit of industrial growth. The situation can be described as the industrial countries overconsuming resources, which are overextracted and exported by developing countries and traded at prices that are often below social costs. The disparity in the use of resources—such as petroleum or agricultural commodities—between industrial and developing regions, the North and the South, is a central problem in economics (Chichilnisky 1994). The key issue now is how to achieve a swift transition to a more sustainable pattern of economic progress, one that avoids replicating resource-intensive patterns of industrialization. There are sound reasons to avoid resource-intensive economic development in the South. Latin America and Africa have followed traditional resource-intensive patterns of growth and lost ground. The successful Asian model has been more knowledge-intensive. It is vital that we achieve a swift transition to knowledge-intensive economic progress, one that uses human capital as the main engine of growth and is compatible with the conservation of the ecological infrastructures that support human life on Earth.

A ray of hope is the advent of a "knowledge revolution" in selected regions, based on explosive increases in the productivity of human capital and on the use of information technology as a fuel (Chichilnisky 1996). In any case the development of forward-looking economic institutions that improve the connections between markets and the environment seems essential to achieve a harmonious relation between humans and the biosphere.

—*Industrial ecology.* An emerging paradigm for guiding the design and evolution of industrial economies is the analogy between industrial systems and ecological systems. The analogy draws primarily on the model of an industrial sector as a process that transforms inputs into outputs. To the extent that the outputs from one activity can be the inputs to another, the need for external sources and sinks can be reduced. In the limit, an economy would require only incoming energy and would emit only entropy. In the largest sense, this must be the long-term state for the planet as a whole. For finite (but depending on the fuel source, possibly very long) periods of time, we can use energy and materials at a rate that is greater than incoming solar radiation, but this only reflects the fact that we have great reserves of energy that has been stored over geologic time.

As an emerging discipline, industrial ecology considers flows of materials and energy through economic systems and searches for ways to minimize the overall impact of that economy on the health of Earth as a whole. Thus there may be situations where the waste or toxicity of a sub-element of an industrial system actually increases. Such increases will be more than offset through improvements in the system as a whole. The methods and units of analysis in industrial ecology are still in their infancy, but their foundation as an integrative endeavor is firmly established. This larger picture has implications that span from individual manufacturing processes to the organization of economies themselves.

Conclusion

The above general description for approaching the study of global systems will help provide the basis for global planning, global engineering and global mitigation. They, in turn, together with more local and regional approaches, provide the basis for wise stewardship of our planet. The main thesis is that we will need to make some very difficult choices within the foreseeable future for which we currently lack the basic underlying physical, ecological, and human system knowledge and the engineering and social tools to implement them. This is not because a catastrophe is predicted, because a central tenet of this paper is that enough is not known to make such a prediction for the Earth system as a whole. Rather it is suggested that in any case difficult choices will be forced upon us by sociopolitical considerations and we need to be careful. These choices have the potential for great impact on the world's wealth generation capacity and biosphere. Mistakes will be very costly in terms of wealth generation and the environment and can have a large impact on social or biosphere stability and thus U.S. and global security.

While not the focus of this paper, it is clear that in the course of obtaining the knowledge we will be redefining our relationship to other species and our role and responsibilities as wise stewards. The spiritual, ethical, and existential dimensions of the changes this will provoke have the potential to be as profound as the impact of Copernicus and Galileo on our perception of our place in the universe. In the end, that impact can be as important as the increased direct knowledge of the Earth/human system to our future well-being and security.

Next steps

There are two reasons that a "going-to-the-moon" systems' approach is more appropriate than the current significant, but fragmented and insufficient efforts. The first is that there are large potential threats to U.S. and global security that could occur as a result of our initiating actions whose consequences are unknown. Can we really afford to continue to gamble? Given what is at stake it would seem appropriate to approach the task of obtaining the needed knowledge and tools with a sense of urgency. Second, the knowledge, engineering and social tools we need require an integrated approach. This paper has described in very general terms, the systems research that needs to be pursued. As explicitly suggested in the introduction, there are questions that need to be answered in order to implement wise stewardship and thus avoid threats to U.S. and global security. The following process is a suggestion to be followed to determine the specific types of programs and levels of effort:

(1) Determine a list of critical systems-related questions evaluated both for importance and for likelihood of obtaining the answer with a research effort.

(2) For each of the critical questions (ranked on the basis of the sum of the rankings of importance and likelihood of progress) develop a research agenda that specifies the types of studies and levels of effort. For important questions where progress will be difficult given the lags in state of knowledge and tools, develop a priority list for longer term investments in knowledge-base building and tool development. In describing the proposed programs, for each question, one should determine the physical, biological and social science components so that one can translate increased knowledge to useful action.

The "going-to-the -moon" character of the proposed efforts might suggest the need for a separate organization to coordinate the program as well as to establish the needed accountability to ensure that the necessary progress is made in a cost-effective manner.

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Global environmental changes

Robert W. Corell

We are the inhabitants of a precious place, planet Earth. As we try to understand what the makes our planet tick, we are confronted with an incredible array of forces and effects that all interact. We need to understand each force and effect, but more importantly we need to see the connectivity among them. The multiplicity of interactions, however, makes it very difficult to sort out the single drivers. We always talk about atmosphere, ocean, and land, but people are now becoming an equal part of the dynamic that causes the Earth to behave in the fashion that it does. In fact, population dynamics and urbanization form an incredible array of drivers that cause the processes to take place.

The time and spatial scales that we have to deal with are incredible, whether it is atmospheric composition that changes over centuries and global scales, or tornadoes that operate, say, in the Oklahoma basin for a few tens of minutes. We care most about the regional or very local scale. If you are living in the Imperial Valley of California, the projected patterns of the next 100 years don't look terribly attractive for adequate water for agriculture and food products that have flourished during the 20th century. These are issues that are real threats to our security as a nation, and frankly the threats to peace around the world.

Fortunately there is a magnificent convergence occurring as the new millennium begins, as new theoretical modeling and observational techniques are coming into use. Massive increases in computer capacity will enable global climate models to look at how the planet works. About a 100-terraflop machine will be necessary to produce global climate model with a 10-kilometer-resolution, and several nations are making heavy investments in the next generation supercomputers.

We also have been making progress on the issue of differences in our climate models. If you ask the climate community using several different models to run projections out into the next century, the divergence of their predictions has narrowed greatly (Figure 12-1). We are homing in; the band of uncertainty among our climate models is getting smaller and smaller. Being able to use the models in retrospect to explain what actually happened in the past is also getting a lot better.

Our capacity to look at global-scale processes will be magnificently transformed through the Earth-observing satellite capability that NASA, Japan, and Europe are developing. The 24 measurements planned in the current incarnation of the Earth Observing Satellite will dramatically change our capacity to understand processes in the ocean, for example.

We have learned interdisciplinary approaches to problem solving from projects undertaken in the International Geophysical Year. This was the first massive attempt to attack issues like understanding the biomes in the northern hemisphere; to bring Third World scientists to the table as we never have before; to assess where we go into the Amazon, not as the United States only or as a few countries, but as a consortium of probably 10–15 nations, looking at a series of land-atmosphere interaction processes. So

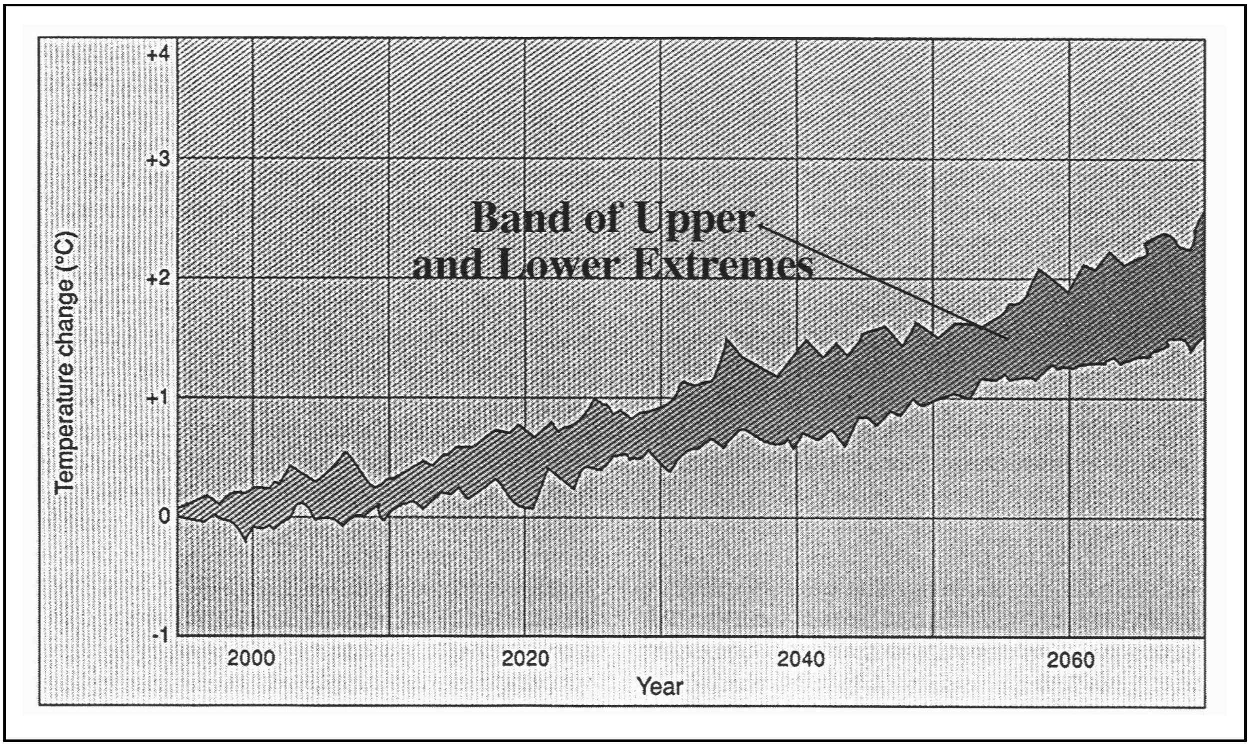


Figure 12-1. The range in predicted change in the global mean surface temperature (C°) for years 2000-2080.

our capacity to get at these problems is clearly improved dramatically over the past, particularly in the past decade.

With this said, I would like to outline some of the global-scale evidence of enduring change, change that challenges science and will challenge us, I suspect, for decades to come. Inevitably we will have to seriously address the connections between man's activities and these changes, but we should also understand and even predict nature's own quirks and changes. These environmental effects will impact our security in both the narrow and broad senses.

Improving predictions: The El Niño example

In the last decade we have gotten a handle on prediction for certain parts of the planet. A massive array of buoys in the central Pacific measures the sea-surface temperature and a series of other parameters that allow us to do some projections about El Niño timing and severity. Several centers around the world and in the United States have done a stunning job in developing and demonstrating this capability.

These predictions are already finding their way into practical use—particularly in the northeast part of Brazil, a region that had traditionally been destitute because of the impact made every 3-7 years by a massive El Niño they could not predict. Today, that region is overcoming its drought sensitivity to El Niño. In 1987, which was a big El Niño year, there was no action taken to mitigate its impact. In 1992, drought resistant seed was used, and there was on the average not only no negative El Niño effect, but even a slight positive effect on grain production. So investments in scientific research have had a beneficial effect and have mitigated some difficult environmental factors.

On the other hand, El Niño has an uncontrollable effect on weather patterns across the United States from tornadoes in Oklahoma to mini-monsoons in the Caribbean and, of course, floods and droughts on our Pacific coast. The effect on our insurance industry and our economy has been devastating. Since 1980, 20 events (floods, hurricanes, earthquakes) have each caused in excess of a billion dollars in damage; the cost alone from hurricane Andrew in 1992 was $16 billion. We still have a great deal to learn before we can control or mitigate these effects.

Natural and anthropogenic change

The planet wasn't always quite the way it is now—and that becomes a part of the argument: what is normal and does that change? Massive variability has occurred on interglacial time scales: Chicago, Boston, and Cincinnati were all under ice; Greenland was 16 degrees centigrade colder on the average; the tropics were 2–5 degrees cooler; sea level was 100 to 110 meters lower than it is today; mountain snow lines were a kilometer lower in the tropics and in the temperate zone; CO_2 levels were 70% of pre–Industrial Revolution levels. Paleo-data allows us to track changes that were natural certainly up into the mid part of the last 1000 years. Then came the Industrial Revolution.

We cannot continue our linear thinking about the planet— thinking that goes, "Things just change." Our planet doesn't necessarily make easily flowing changes. For example, in the North Atlantic, glaciers melted about 11,000 years ago, creating much less-dense cold surface water, stopping the formation of cold deep-ocean currents, and dropping the temperature in Europe by probably on the order of 6–7 degrees centigrade. This abrupt change is evidence that the planet is metastable; it pops into different states. It popped four degrees in ten years during the glacier melt, according to sediment records.

The planet does respond rapidly. Two weeks after Pinatubo erupted sulfur dioxide wrapped the planet in a belt. The mixing and convective processes of the planet are pretty rapid. This had a cooling effect, produced by all those particles. The sun reflects off of them and doesn't get to the Earth's surface. Pinatubo had a massive effect and caused a measurable cooling. If you look at the temperature record ten years from now, you will see the Pinatubo effect. In fact you can see the leveling off for three or four years of the rising global temperature because of Pinatubo.

Carbon dioxide is sufficiently well mixed that we don't need 5000 measuring stations around the Earth to understand what is happening with it. A few stations adequately cover the trends. Human behavior in the economic world can be detected in the CO_2 change; it is very small, but it is easy to see. Look at the oil crisis of 1973; you can actually see it in the global CO_2 record.

The remainder of this discussion argues that things are changing on a global scale. Whether these are naturally occurring phenomena, anthropogenic, or both, we need to understand them better. How significant are the changes and what are the key drivers? We don't want to put our energy, money, and time on things that are less important. But once we know the answers to these questions, we as citizens of nations of the world are going to have to face them and change the way in which this planet is evolving.

Greenhouse gas accumulation. CO_2, carbon fluorocarbons (CFCs), and methane have been going up at rates approaching a percent a year. CFC increases, which were going up at 5% per year globally, are starting to level off. Methane is going up at 1%. If you put your money in the bank at 1%, you don't do very well, but if you put greenhouse gases in the atmosphere and compound it over decades, the effect is dramatic. CO2 growth over the Industrial Revolution is on the order of 25–30%

To control CFCs, nations of the world did respond. In the mid-1980s scientists started saying that the projections about CO_2 effects were starting to be seen. Then we had the summer of 1988, one of the hottest summers in Washington, D.C. Senator Gore and many others started holding hearings and there was a lot of hype; we ended up with a convention on climate that was signed in Rio.

President Bush had only one White House conference and it was on global warming. President Clinton has had probably upwards of ten conferences dealing with climate-related issues. The next major international summit will be in Kyoto in November, 1997.

North America, Western Europe, and the former Soviet Union started generating considerable CO_2 during the 20th century. China, Brazil, and India have now entered the picture. Indonesia, with the fourth largest population of the world, has not yet begun to generate CO_2 measurable on the global scale. These are the comers, the countries that aspire to the lifestyle to which we are accustomed. They are going to invest in energy, in ways that are not unlike what we have done.

Ozone decrease and UV radiation increase. The Southern Hemisphere ozone maps are familiar. But the Northern Hemisphere is now also experiencing ozone depletion over Russia, the United States, and Greenland (Figure 12-2). The fundamental processes that drive this effect are undoubtedly the same here as over Antarctica, but the dynamics of the Northern Hemisphere are different. There is no northern polar vortex to contain the ozone hole. In fact, we now know that depletion reaches down well into our latitudes during certain times of the year.

Northern stratospheric ozone is down 4–5% and UV-ray radiation is going up at the rate of 4–9% per decade. There is controversy, but the UV numbers are increasing. This is not a healthful development. Fortunately, we do have evidence suggesting that CFC controls will cause this to level off in the decades ahead.

Glacier retreat. There is really good satellite data that shows the reduction in glacial area around the planet. The higher altitudes are even more dramatically affected, but on average glaciers are retreating, consistent with a warming climate.

A couple of years ago in Antarctica, an iceberg calved off the peninsula near Palmer Station, one of the stations that the National Science Foundation supports. This region has warmed on the average 2.5-3 degrees centigrade since roughly the mid to late 1940s, roughly a 2.5^{o}C growth in temperature over 50 years. Some observers will argue, quite persuasively, that some of this calving is driven by the local warming trend.

Precipitation pattern change. We predict a 20% increase in precipitation in the northeast United States and a 10-20% drop in California (Figure 12-3). It appears that we are going to have many more floods in the Mississippi watershed.

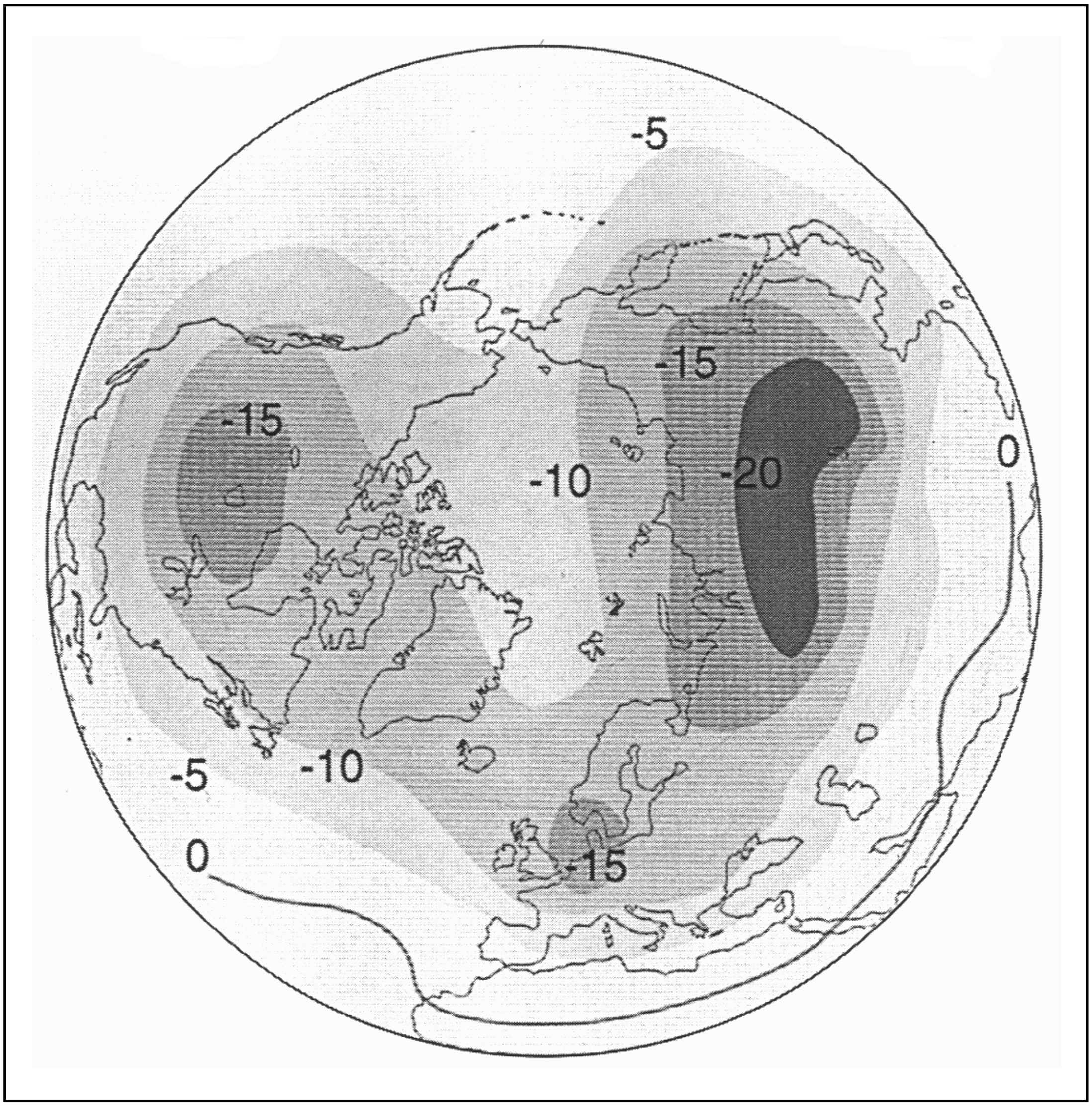


Figure 12-2. Ozone depletion in the northern hemisphere.

Sea level rise. Sea level is on the upward trend as measured in Japan; Honolulu; Sydney, Australia; Bombay, India; San Francisco; and France (Figure 12-4).

Vegetation decrease. Brazilian Amazonia is experiencing major changes in land use. Maybe this is the right thing to do, but at least we now have the satellite data to see what is happening. Human-induced land use degradation, overgrazing, and deforestation, are common in Asia, Africa, and South America (Figure 12-5). In the short time of human history a 20% reduction in vegetated land has occurred. We have changed the pattern in which we use our bioresources, not on a local scale, but on a global scale. The idea of a global threat is a suitable paradigm in this case.

Disease mobility. There is increasing evidence that there is connectivity between climate change and other global environmental phenomena and human health. As the

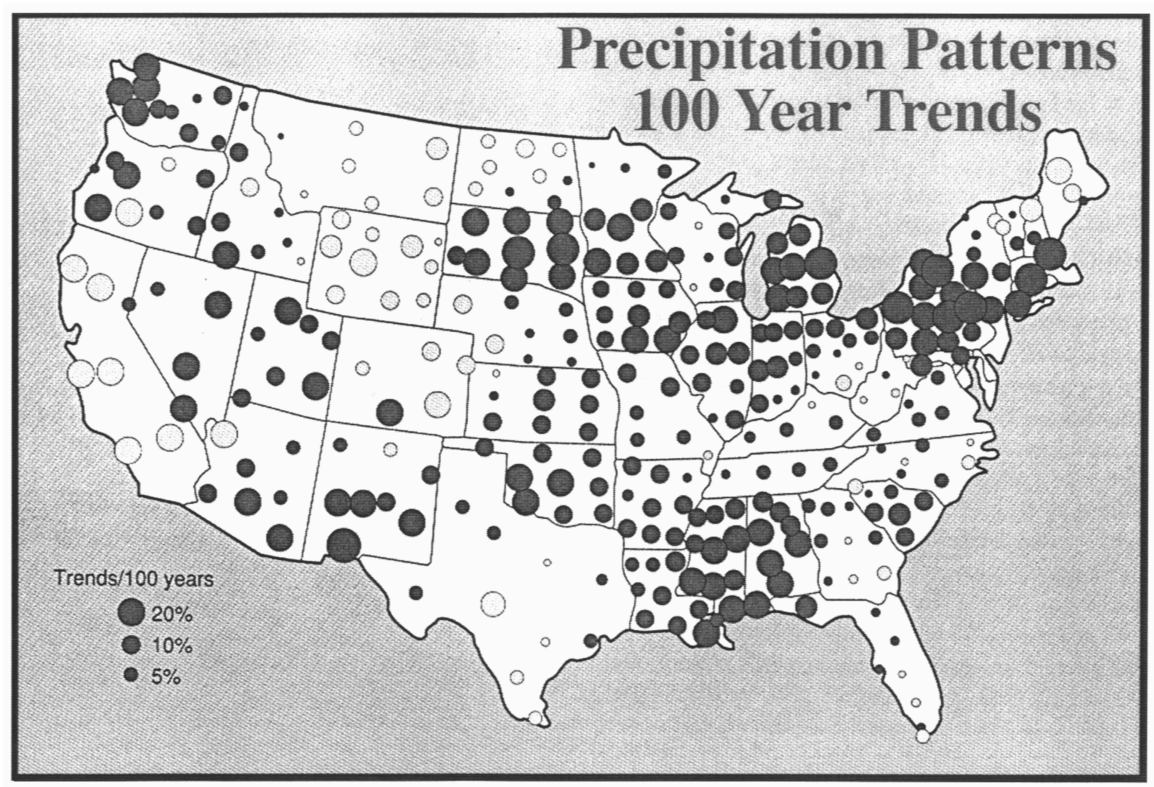


Figure 12-3. 100-year trends in precipitation patterns.

temperature rises to a certain level, disease vectors increase and start moving; they are very temperature sensitive. Diseases are appearing in the Northern Hemisphere that weren't there before.

Research agenda

Some issues that underlie environmental threats to our national security are pervasive and important across the world. From the perspective of the National Science Foundation, which tends to focus on basic research, and of the other agencies who have responsibility of developing research agenda and making investments in global change science, the discussion and development of a focused national R&D agenda is very important.

I can tell you that those of us who convert agenda into programs, like U.S. global change research program, or the Mission to Plant Earth at NASA, or the geosciences and other disciplines at NSF and our fellow agencies, derive great help from these discussions. We need to focus on the research priorities for this complex array of environmental security issues.

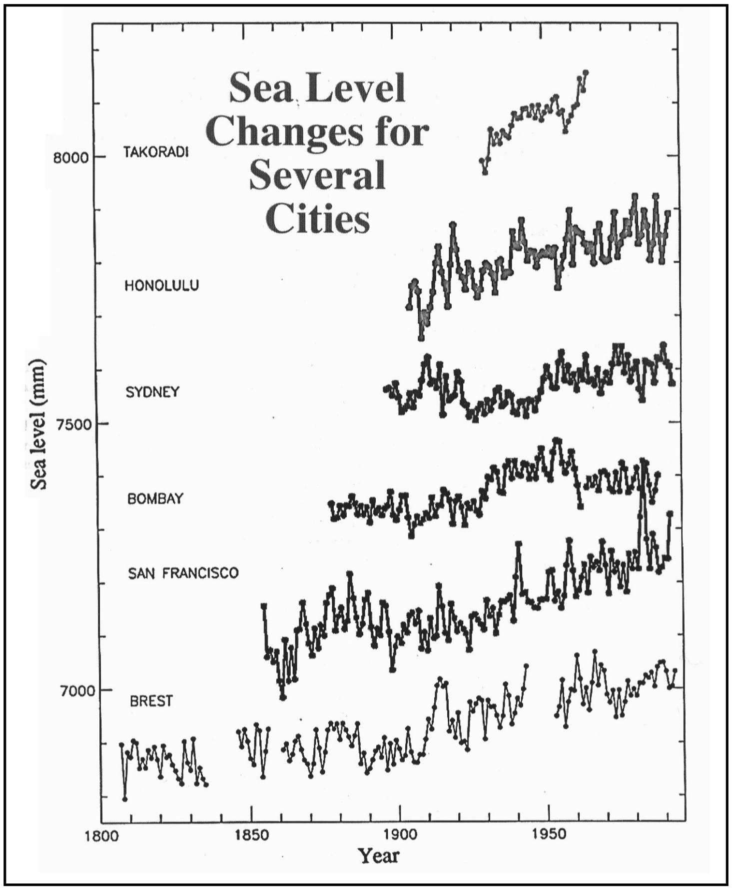


Figure 12-4. Changes in sea level around the world.

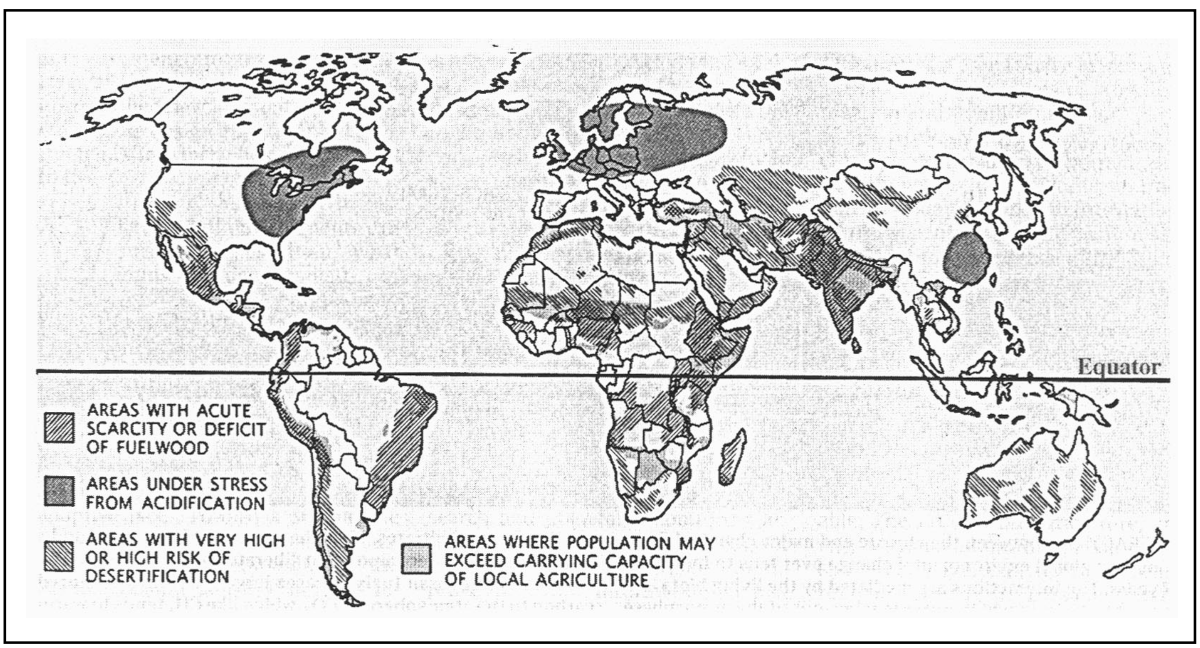


Figure 12-5. Worldwide areas of environmental stress.

Global observing strategies

Robert C. Harriss

Recent technological advances in space-based remote sensing, scientific information systems, and communications ensure global observing capabilities an essential role in contributing to the characterization, mitigation, and prevention of environmental problems that threaten human welfare. In addition, remote sensing capabilities can promote a more efficient and effective use of natural resources, thus minimizing some of the preconditions of environmental degradation and related crises.

Clearly, enhanced scientific understanding through improved information gathering is only one of many elements needed to meet sustainable development imperatives and forge stable international and intranational communities. But even the most simplified framework of key strategic interventions includes scientific, as well as sociological, political, and economic dimensions.

For the United States, specifically, Earth remote sensing offers numerous benefits that can be grouped beneath the umbrella of environmental security:

• Avoid commodity surprise: U.S. vulnerability to "surprise" in essential commodities can be reduced. The evolution of the global economy continues to increase U.S. involvement in global markets for food, energy, and other commodities. Information on the availability and quality of commodity supplies is not only essential for our security, but economically advantageous.

• Monitor critical instabilities: Regions at risk because of environmental or economic stress can be monitored in almost real-time for purposes of assessment, planning, and response management.

• Predict the weather: The impact of accurate, local, longer-range weather forecasts on disaster preparedness and response, agriculture, travel, even energy management would be very beneficial in terms of health and safety, property protection, and economic efficiency.

• Promote international cooperation: Increased cooperation among national and international organizations would accelerate technical progress on Earth monitoring and build international confidence in cooperative environmental issues. The evolution of an International Global Observation Strategy is a particularly important challenge.

Advances in space-based remote sensing

For national security reasons, civilian remote-sensing imagery did not in the past provide the spatial resolution that is required to assess many of the intense, small-scale environmental threats. The end of the Cold War has resulted in relaxed limits on the spatial resolution of civilian systems. Existing and soon to be launched scientific and commercial spaced-based imaging systems will provide both panchromatic and multispectral imagery that will resolve objects that are less than one meter in size. Geodetic accuracy of tens of meters and stereo-optic capability will also be common.

<u>Cloud penetration and improved spectral resolution.</u> Cloud cover and limited

spectral resolution of remote sensing systems no longer prevent monitoring of key environmental indicators. Remote sensing data are currently available from commercial and scientific optical, radar, and passive microwave measurements. Radar data can provide a wide variety of ecosystem and environmental measurements under all weather conditions, day and night. High spectral resolution measurements will become widely available within the next few years. High spectral resolution optical measurements show great promise for monitoring crop status, ecosystem health, and many environmental quality issues.

More frequent data updates. The current proliferation of Earth- observing satellite systems will mean that revisit times for imagery of any particular geographic location are being significantly reduced. Revisit times of less than five days are already available for many geographic locations.

Speedier data delivery. The rapid growth of the commercial remote sensing industry, along with increased scientific interest in using a wider range of data for operational environmental forecasting, has significantly increased the timeliness of remote sensing data delivery to the user. Products from most commercial imaging systems can now be delivered to the user in days. An increasing number of commercial sensors, and improvements in data transmission and processing infrastructure, will continue to reduce data delivery times, making possible such priority applications as crisis management.

International and commercial systems coming on line

Landsat is the best known, and continues to be a widely used, source of satellite data for environmental applications. Five Landsat satellites have been launched successfully by the United States since 1972. Landsat 6 was lost during launch. Landsat 7 will be launched in 1998. This series of satellites has provided a wealth of unique scientific information for studies of land cover and land-use change, geological mapping and analysis, urban and regional planning, and data for other research and commercial applications. Landsat data also serves some military planning and operations requirements such as traffic analysis and high-precision map making and terrain. Landsat's multispectral scanner with 50-meter resolution and its thematic mapper with 30-meter resolution have been widely used for scientific and commercial applications.

France was the second country to field a continuing, widely available surface imaging capability. The French satellite series, Satellite Pour l'Observation de la Terre (SPOT), has been in operation since 1986. The SPOT 1 satellite used charge-coupled device detectors with 10-meter panchromatic spatial resolution and 20-meter multispectral imagery.

Remote sensing imagery is now available from India, Russia, Canada, Japan, and the European Space Agency, all of which have active Earth observation programs. Brazil, Argentina, China, and several other nations plan to launch remote sensing instruments before the turn of the century. If all the government and commercial land imaging satellites are launched as currently planned, more than 15 satellites will be providing data in panchromatic, multispectral, and radar formats as soon as the year 2000. Table 13-1 provides basic information on most of the current and approved international land remote sensing satellites. The recent availability of all-weather surface

Table 13-1. New international land data satellites.

Country	Owner /OBJ	Program	Sched Date	Inst Type	Resolution in Meters P	M	R	#Color Bands	Stereo Type
FRANCE	G/O	Spot 5B	'04	P&M	5	10		4	F/A
U.S.	G/O	EOS AM-2 / L-8	'04	P&M	10	30		7	
FRANCE	G/O	Spot 5A	'99	P&M	5	10		4	F/A
INDIA	G/O	IRS-1 D	'99	P&M	10	20		4	C/T
U.S.	C/O	Space Imaging	'98	P&M	1	4		4	F/A
KOREA	G/O	KOMSAT	'98	P&M	10	10		3	F/A
U.S./JAPAN	G/O	EOS AM-1	'98	M	15	15		14	F/A
U.S.	G/O	Landsat-7	'98	P&M	15	30		7	
ESA	G/O	ENVISAT	'98	R			30	0	
U.S.	C/O	Space Imaging	'97	P&M	1	4		4	F/A
U.S.	C/O	Eyeglass	'97	P	1				F/A
FRANCE	G/O	Spot 4	'97	P&M	10	20		4	C/T
U.S.	C/O	EarthWatch	'97	P&M	1	4		4	F/A
U.S.	C/O	EarthWatch	'96	P&M	3	15		3	F/A
U.S.	G/E	CTA Clark	'96	P&M	3	15		3	F/A
U.S.	G/E	TRW Lewis	'96	P&M	5	30		384	
RUSSIA	G/O	Almaz 2	'96	R			5		
JAPAN	G/O	ADEOS	'96	P&M	8	16		4	C/T
CHINA-BRAZIL	G/O	CBERS	'96	P&M	20	20		7	C/T
CANADA	G/O	Radarsat	'95	R			9		
INDIA	G/O	IRS-1 C	'95	P&M	10	20		4	C/T
CHINA/BRAZIL	G/O	CBERS	'95	P&M	20	20		7	C/T
RUSSIA	G/O	Resours-02	'95	M		27		3	

NOTES:
Multispectral only — M
Pan & Multispectral — P&M
Panchromatic Only — P
Radar — R
Government Funded — G
Commercially Funded—C
Operational — O
Experimental — E
Fore & Aft Stereo — F/A
Cross Track Stereo — C/T

imaging capability using radar from Russian, Japanese, European, and Canadian satellites is a particularly significant recent advance.

The next few years will see a rapid growth in space-based commercial imagery systems. Several commercial organizations in the United States have announced plans to launch satellites with improved spatial resolution and more frequent revisit times than is available currently. The primary markets being targeted by commercial firms are urban and regional planning and agriculture. It is obvious that the imagery from such satellites can also support many environmental, military, and economic intelligence applications that are not time critical.

Technological trends in land remote sensing from space

The brief description above of selected Earth observation capabilities illustrates several important trends.

• There will be a proliferation of space-based sensors with enhanced atmospheric, land, and ocean imaging capabilities in the next few years. International spending on space has already reached substantial levels, is increasing, and cost-sharing agreements between governments are reducing the cost of access to space for new ventures.

• Commercial organizations are playing an increasingly important role as providers of imagery for both research and applications. Commercial imaging systems are also moving toward higher spatial resolution and faster data delivery than has been available from most government-operated systems.

• The increasing capability of civilian remote sensing in the areas of spatial resolution, spectral coverage, revisit time, and data-delivery time will dramatically enhance opportunities for environmental research and applications.

It should be clear that technology will not be a serious limiting factor to making progress on both domestic and international efforts to increase the effectiveness and efficiency of management of natural resources. High-precision agriculture and forestry are rapidly becoming a reality where private and state organizations can afford the price of the knowledge and technology. Widespread implementation of resource management tools that increase efficiency of use of inputs to production, such as, fertilizers and water, will significantly reduce pollution residuals. The United States has already made significant progress at reducing environmental threats on our own territory over the past several decades.

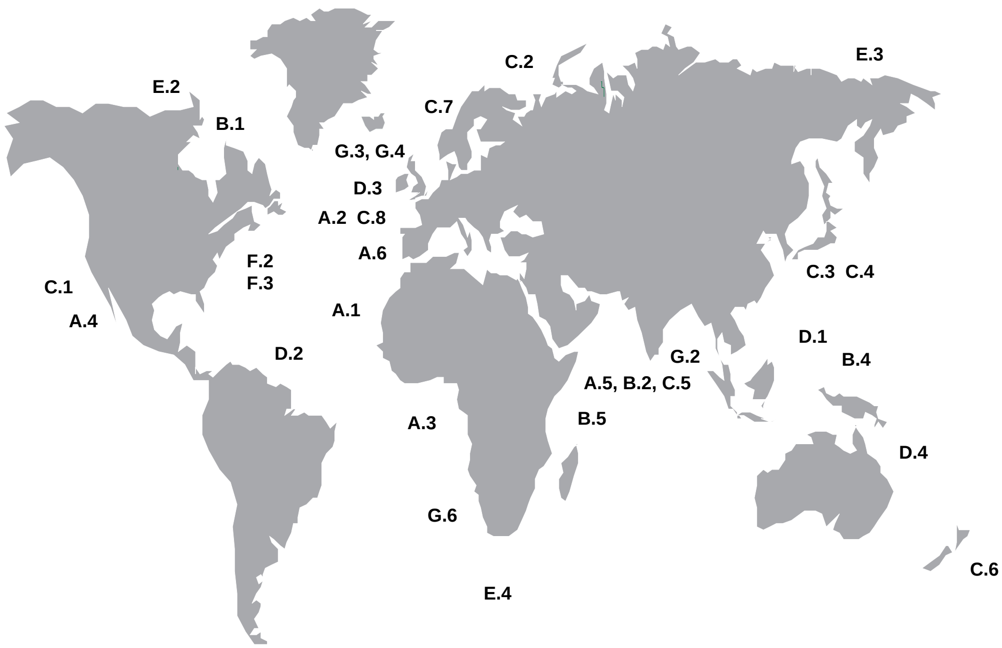
The diffusion of Earth remote sensing technologies to developing countries is limited primarily by the initial cost of data capture, data processing, and scientific information infrastructure. With major states like Russia, China, and India, which have near state-of-the-art capabilities, socioeconomic and political factors may be more important than technological capability.

Conclusions

Remote sensing data can contribute to the characterization, mitigation, and prevention of some natural resource and environmental degradation. A brief, qualitative summary of examples of recent applications of remote sensing to such problems is provided in Figure 13-1 and Table 13-2. These technologies and their applications are too new, and evolving too rapidly, to draw firm conclusions on their effectiveness for dealing with the entire range of environmental security issues. Still, several observations are supportable:

1. Remote sensing data can be a powerful tool for documenting change in land cover and land use. High spatial and spectral resolution satellite data will become widely available in the next few years, contributing to further advances in the descriptive analysis of changes in earth surface properties, such as topography, vegetation, and pollution.
2. Remote sensing can be useful for the rapid assessment of available natural resources, such as food, water, grazing lands, and biomass resources, that might cause or mitigate a crisis and lead to population migrations.
3. Integration of remote sensing data with surface weather and climate data, and with socioeconomic data in a geographic information system can contribute significantly to an understanding of spatial relationships between cause and effect variables, and to the understanding and anticipation of future conditions.

The expansion of commercial remote sensing industries around the world will accelerate progress on reducing local environmental threats. The commercial sector will



A Agriculture
- **A.1 ALIS - Egyptian agricultural land information service**
- **A.2 Sugar beet monitoring**
- **A.3 ARTEMIS - real time environmental monitoring in Africa**
- **A.4 Inventory of agriculture and irrigated lands in Kansas**
- **A.5 CAPE - crop acreage estimation and production forecasting in India**
- **A.6 MARS - monitoring agricultural statistics in the EC**

B Resource management and surveying
- **B.1 Geological structure identification and mapping**
- **B.2 Drinking water provision for India's rural population**
- **B.3 Offshore oil exploration**
- **B.4 Tropical forest inventory**
- **B.5 Vegetation data dissemination in Ethiopia**

C Hazard monitoring and disaster assessment
- **C.1 Volcano hazard alert plan**
- **C.2 Monitoring the Chernobyl disaster area**
- **C.3 Earthquake prediction in China**
- **C.4 Forest and grassland fire detection**
- **C.5 NADAMS - agricultural drought assessment and monitoring**
- **C.6 Damage assessment of cyclone in New Zealand**
- **C.7 Oil spill monitoring using ERS SAR images**
- **C.8 Flood monitoring and prediction using ERS I**

D Civil mapping and planning
- **D.1 Natural resources mapping of the Philippines**
- **D.2 Mapping of French Guyana**
- **D.3 Land cover map of Great Britain**
- **D.4 Landcover change in Australia**

E Ice monitoring
- **E.1 Ice monitoring by the US National Ice Centre**
- **E.2 Operational ice reconnaissance and forecasting in Canadian waters**
- **E.3 Operational sea-ice monitoring on the Northern Sea Route**
- **E.4 Real-time ice monitoring in the Antarctic**

F Coastal zone management
- **F.1 Coast Watch**
- **F.2 Coastal change analysis**
- **F.3 Coastal development monitoring on the Georgia-South Carolina seaboard**

G Oceanographic applications
- **G.1 Fishery utilization of remote sensing data in Japan**
- **G.2 Fishing zone forecasting in India**
- **G.3 Offshore pipeline routing**
- **G.4 Sea state forecasting for offshore operation**
- **G.5 Ship route optimization using ERS data**
- **G.6 Real-time monitoring of potential fisheries (Lake Malawi and Namibia)**

Figure 13-1. Examples of remote sensing applied to problems of environmental security.

focus on reducing costs and ensuring timely data delivery. State research organizations will conduct the basic research necessary for radically new applications.

Table 13-2. Brief summaries of remote sensing capabilities referenced to the environmental security applications given in Figure 13-1.

Instrument (platform)	Application (project index)	Instrument type	Instrument characteristics
AMI Scatterometer mode (ERS-1)	G 4	Wind scatterometer	Waveband: Microwave: 5 3GHz. C-band, VV polarisation Spatial resolution: Cells of 50km x 50km at 25km intervals Accuracy: Wind direction: ±20° Wind speed: ±2m/s or 10% Duty cycle: Depends upon the use of AMI for SAR images Swath width: 500km Date rate: 500kbps
AMI-SAR Image mode or wave mode (ERS-1)	A.6, B.1, B.3, C.7, C.8, D.2, E.1, E.2, E.3, E.4, G.3, G.4, G.5	Imaging radar	Waveband: Microwave: 5.3GHz, C band, VV polarisation Spatial resolution: 30m; Duty cycle: 10% nominal for image mode, wave mode depends on the use of AMI for SAR images Swath width: Image mode: 100km, Wave mode: 5x5km at 200km intervals Data rate: 105Mbps (image); 370kbps (wave mode)
AVHRR Advanced Very High Resolution Radiometer (NOAA)	A.3, A.6, B.5, C.1, C.3, C.4, C.5, D.4, E.1, E.2, E.3, E.4, F.1, G.1, G.2, G.6	Imaging multi-spectral radiometer (visible/IR)	Waveband: Visible: 580-680nm, NIR: 725-1100nm, SWIR: 3.55-3.93µm, TIR: 10.3-11.3µm, 11.4-12.4µm Spatial resolution: 1.1km (ssp). Compressed Global Area Coverage (GAC) data recorded at 4km resolution Swath width: 3000km (approximate) 55.4 deg scan off nadir Duty cycle: 100% Data rate: 66.5kbps for GAC, 665.4kbps for HRPT
HRV High Resolution Visible (SPOT)	A.1, A.2, A.6, B.4, C.2, C.6, C.8, D.1	High resolution imager	Waveband: Visible: 500-590nm, 610-680nm NIR: 790-890, Panchromatic 510-730nm Spatial resolution: 10m (panchromatic) or 20m Duty cycle: Daylight coverage only (world wide coverage using on board tape recorder). 100% in daylight. 26 day orbital cycle Swath width: 117km (ie 60+60km with 3km overlap). Data rate: 25Mbps There are two identical HRV instruments on SPOT each of which can point off-track by ±27° enabling stereoscopic coverage.
LISS I/II Linear Image Self-Scanning System (IRS 1A/1B)	A.5, B.2, C.5	High resolution imager	Waveband: Visible: 460-520nm 520-590nm 620-680nm NIR: 770-860nm Duty cycle: 100% (daylight). Revisit time 22 days (11 days both) Spatial resolution 72 5m (LISS I), 36 25 (LISS II) Swath width 148km (LISS I), 145km (LISS II) Data rate 5 2Mbps (LISS I), 2×10 4Mbps (LISS II)

Table 13-2. (Continued.)

Instrument (platform)	Application (project index)	Instrument type	Instrument characteristics
MESSR Multispectral Electronic Self Scanning Radiometer (MOS 1b)	B 4	High resolution imager	Waveband: Visible 510-590nm, 610-690nm; NIR: 730nm-800nm, 800nm-1100nm Spatial resolution: 50m Swath width: 100km (200km when both camera systems are operating) Data rate: 9Mbps
MSS Multi-spectral Scanning System (LANDSAT)	A.5, B.4, D.4, F.3	High resolution imager	Waveband: Visible: 500-600nm, 600-700nm; NIR: 700-800nm, 800-1100nm Spatial resolution: 80m in visible and NIR channels Duty cycle: 30% Swath width: 185km Data rate: 15Mbps
MSU-E Multispectral Scanner Electronic scanning (Resource)	C.2	High resolution imager	Waveband: Visible: 500-600nm, 600-700nm; NIR: 800-900nm Spatial resolution: 45m (at nadir) Accuracy: 4% radiometric accuracy Duty cycle: Programmable Swath width: 45m (one scanner), 80m (two scanners); pointable ±30° from nadir Data rate: 11Mpbs (3 channels)
MSU-SK Multispectral Scanner conical scanning (Resource)	C.2	Imaging multi-spectral radiometer (visible/IR)	Waveband: Visible: 550-600nm, 600-700nm; NIR: 700-800nm, 800-1100nm; TIR: 10.3-11.8μm Spatial resolution: Visible-NIR: 170m; TIR: 600m Accuracy: 4% radiometric accuracy Duty cycle: Programmable Swath width: 600km Data rate: 11.5Mbps (5 channels)
Multispectral Visible and IR Scan Radiometer (10 channel) (FY-1)	C.3	Imaging multispectral radiometer (visible/IR)	Waveband: Visible: 430-480nm, 480-530nm, 530-580nm, 580-680nm; NIR: 840-490nm, 900-965nm, 1.58-1.68μm; SWIR: 3.55-3.93μm; TIR: 10.3-11.3μm, 11.5-12.5μm Spatial resolution: 1.1km Duty cycle: 100% Swath width: 3200km Data rate: 1.3308Mbps
MVIRI METEOSAT Visible and Infra-Red imager (METEOSAT)	A.3, B.5, C.1	Imaging multispectral radiometer (visible/IR)	Waveband: Visible: 500-900nm; TIR: 5.7-7.1μm (water vapour), 10.5-12.5μm Spatial resolution: Visible: 1.25km; TIR: 5km (after processing) Duty cycle: Full Earth in all three channels, every 30 min Swath width: Full Earth disc Data rate: 333kbps

Table 13-2. (Continued.)

Instrument (platform)	Application (project index)	Instrument type	Instrument characteristics
OLS Operational Line-scan (DMSP)	E.1	Operational line-scan System (visible to near IR/thermal IR)	Waveband: Visible 400-1100nm TIR 10.5-12.5μm Spatial resolution: TIR 560m Duty cycle: 100% Swath width: 3000km
RA Radar Altimeter (ERS-1)	B.3, E.4, G.4, G.5	Radar altimeter	Waveband: 13.8GHz, K band Spatial resolution: 7km Accuracy: Wave height: 0.5m or 10% (whichever is smaller) Sea surface elevation, better than 10cm Duty cycle: 100%
SSM/I Special Sensor Microwave Imager (DMSP)	E.1, E.2, E.3, E.4	Passive microwave imager	Waveband: 19.35GHz, 22.23GHz, 37GHz, 85.5GHz Spatial resolution: 25-50km Swath width: 1394km
TM Thematic Mapper (LANDSAT)	A.2, A.4, A.6, B.2, B.4, C.2, C.8, D.3, F.2, F.3	High resolution imager	Waveband: Visible: 450-520nm 520-600nm 600-690nm NIR: 760-900nm SWIR: 1.55-1.75μm 2.08-2.35μm TIR: 10.4-12.5μm Spatial resolution: Vis and SWIR: 30m TIR: 120m Accuracy: Radiometric: 10% Geometric: 500m Duty cycle: 30% Swath width: 185km Data rate: 84.9Mbps
VISSR Visible and Infra-Red Spin Scan Radiometer (GMS)	C.1, C.3	Imaging multispectral radiometer (visible/IR)	Waveband: Visible: 550-900nm TIR: 0.5-7.00μm 10.5-11.5μm 11.5-12.5μm Spatial resolution: Visible 1.25km, IR: 5km Duty cycle: Full Earth all channels every hour Swath width: Full Earth disc
VISSR & VAS Visible and Infra-Red Spin Scan Radiometer/ Atmospheric Sounder (GOES 7)	C.1	Imaging multispectral radiometer (visible/IR) and Atmospheric sounder	Waveband: Imaging: Visible: 550-750nm TIR: 11.0μm ± 2 IR selectable from 3.9, 6.7, 7.3, 12.7 and 13.3μm Sounder: 1 visible and 12 IR: (3.9 to 14.7μm) Spatial resolution: Visible: 1km IR: 7km and 14km Duty cycle: 100% Swath width: Horizon to horizon Data rate: 240Mbps

Part four: Regional dimensions

Regional dimensions of environmental security

Donald Kennedy

A group of us at Stanford, working with the Carnegie Commission on the Prevention of Deadly Conflict, is trying to develop predictive measures for identifying potential loci of environment-related regional conflict. As a newcomer to this business, I want to record first our great respect for the work of others (in particular, the Toronto–Wilson–American Association for the Advancement of Science axis) who have developed such valuable case studies and historical data on the relationship between environmental quality and regional security problems. Their studies have helped us immeasurably in forming our own approach.

I shall pass quickly over the overworked question of whether environmental security is merely a cover to try to promote a green agenda into the domain of high politics. No matter how you slice it, environment will matter. The world population in 2050—the year in which my current undergraduates will be the age Bob Dole is now—cannot be less than 80% larger than the present one, and may be twice as large. This horde of people, most of them in what we now call the developing world, will be trying to extract more per capita than their predecessors from a set of finite, often common-property, resources. They will be doing this against a background of relentless change: in climate, in land cover, and in the biotic environment. At the same time, they will be contending with old hatreds: religious, ethnic, and class. If you don't believe that scarcity and environmental deterioration will add combustible material to these historic sources of tension, nothing that follows is likely to interest you.

The approach I will discuss is fairly simple-minded, and very much a work in progress. The idea is to construct, from existing data bases, maps of the world that display the distribution of various important environmental and population parameters. Similar maps are created to reflect traditional enmities, histories of conflict, and zones of political instability. When these maps are laid over one another, in a kind of reverse gap analysis, the regions of overlap should be ones in which there is a significant prospect for future security problems. The exercise is not so very different from the one we perform in our heads when, for example, we recognize that the combination of historic tensions and acute developing water shortages makes the Middle East a hot spot. The difference is that in other regions and for more distant futures, the coalition of tension-generating variables may be much more complex: age-distribution and fertility rates of local populations, liability to sea-level rise due to global climate change, deforestation, vulnerability to epidemic disease, to mention only a few.

Background

The present status of world conflict tells us something about what to look for. Of 30 wars currently under way (a war is defined as a violent conflict entailing over 1000 battle deaths per year) not a single one is a contest between nation-states. As the current difficulties in Bosnia and in Middle East emphasize, ethnic differences and traditional enmities have little relationship to national boundaries. The Caucasus, with its welter of newly independent states and its patchwork of ethnic and religious affinities, is another example. Both also illustrate another feature: that the distribution of common-property resources and the occurrence of environmental problems are also unrelated to political divisions.

The distribution of fresh water is a particularly clear example. Over 70% of the world's habitable land surface lies in multinational river basins. In some cases (the Colorado, and more recently the Ganges) negotiations have yielded allocation agreements between upstream and downstream states—however "fair" these may appear years after they have been signed. But in many others there are no agreements at all. Upstream states in the past have done, or threatened to do, all of the following to downstream states: pollute the water, take it for interbasin transfers, impound it and limit flow, impound it and then release it deliberately to provoke downstream flooding.

Figure 14-1 shows a map of the rivers of Southern Africa, with the national

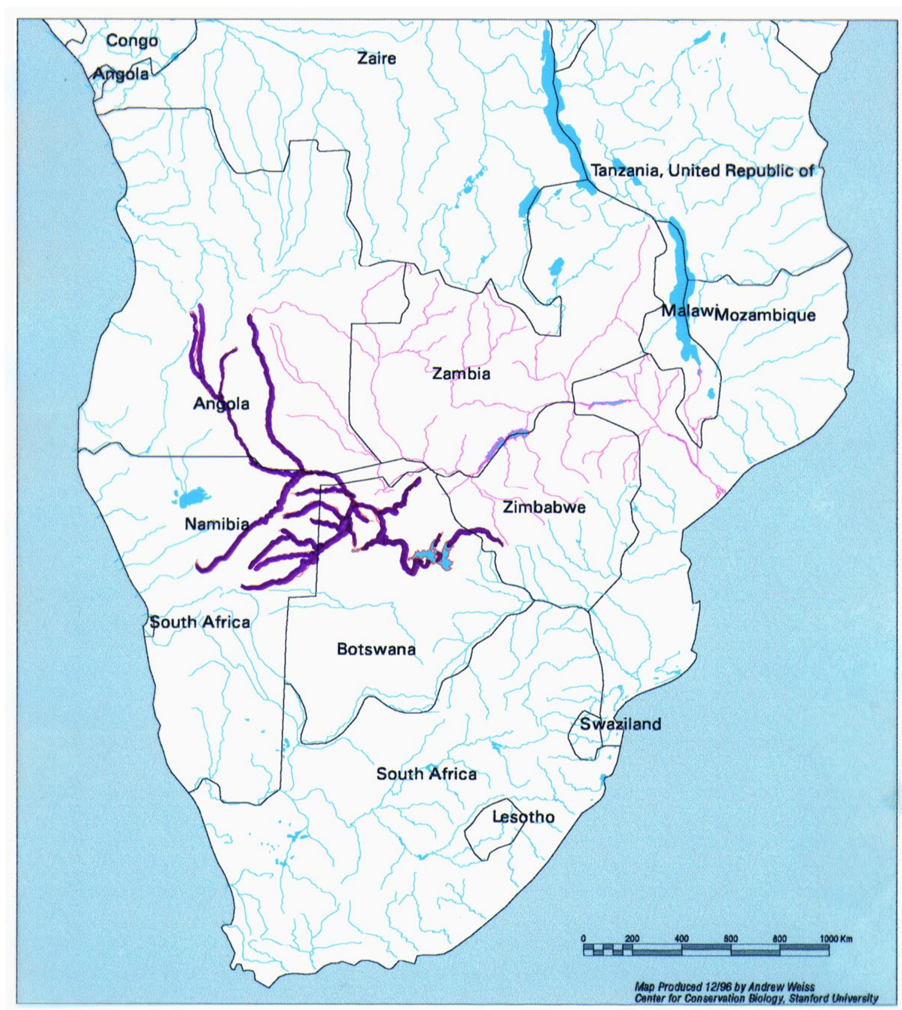


Figure 14-1. Okavanga and Zambesi River systems in southern Africa.

boundaries indicated. Note that the Zambezi is shared by eight nations—all of whom fear that a ninth nonriparian nation, South Africa, has designs on it for interbasin transfers. In the highlands of land-locked Lesotho, Peter Gleick reports, plans for an interbasin transfer to the metropolitan north of South Africa has produced angry resistance from riparians on the Orange River, far to the east. Five South African rivers flow through Kruger National Park before supplying southern Mozambique with much of its fresh water. The Okavanga is shared by Angola; Namibia, which wants to divert some of it; and Botswana, where it ends in a "delta" that is the country's main tourist attraction. In NONE of these cases is there any international agreement respecting allocation.

That is barely a start on one problem, on one continent. I hope it illustrates both the complexity of the challenge, and its seriousness. Now I turn to some of the important variables of population and environmental quality.

Population

It stands to reason, I think, that the numbers of people in an area, the rate at which the numbers are expanding, and the other characteristics of the population will be important to future stability. Figure 14-2 is a fairly standard map of population

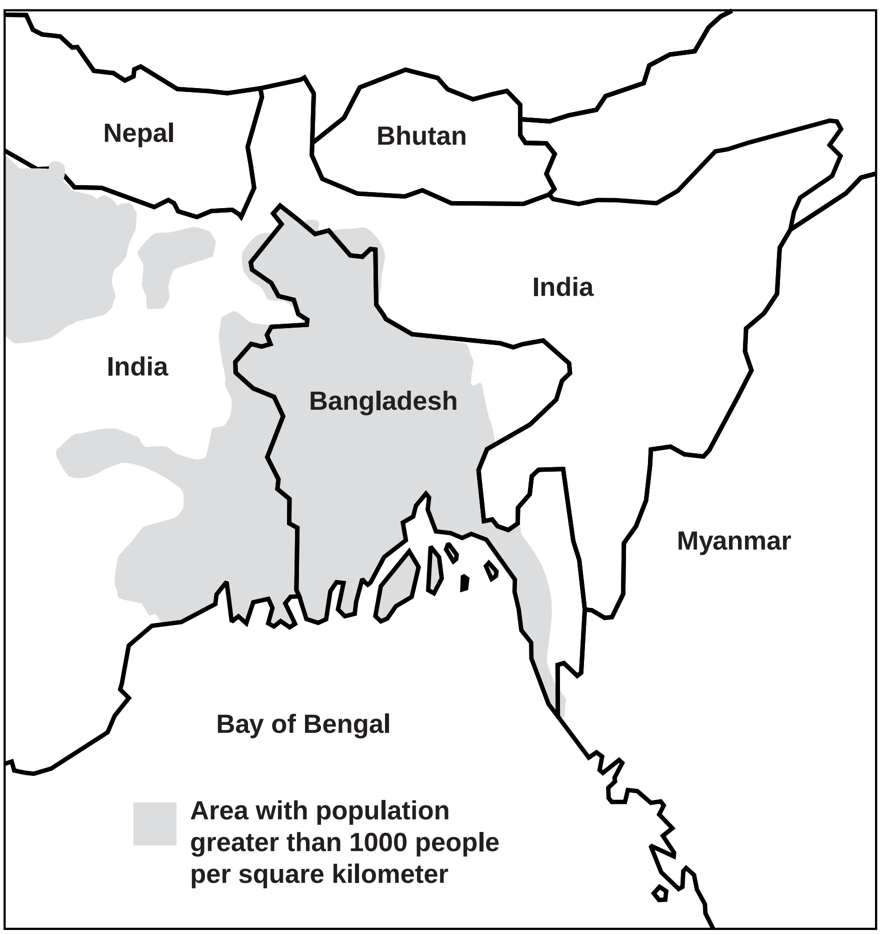


Figure 14-2. Population distribution in the region of the Brahmaputra-Ganges delta.

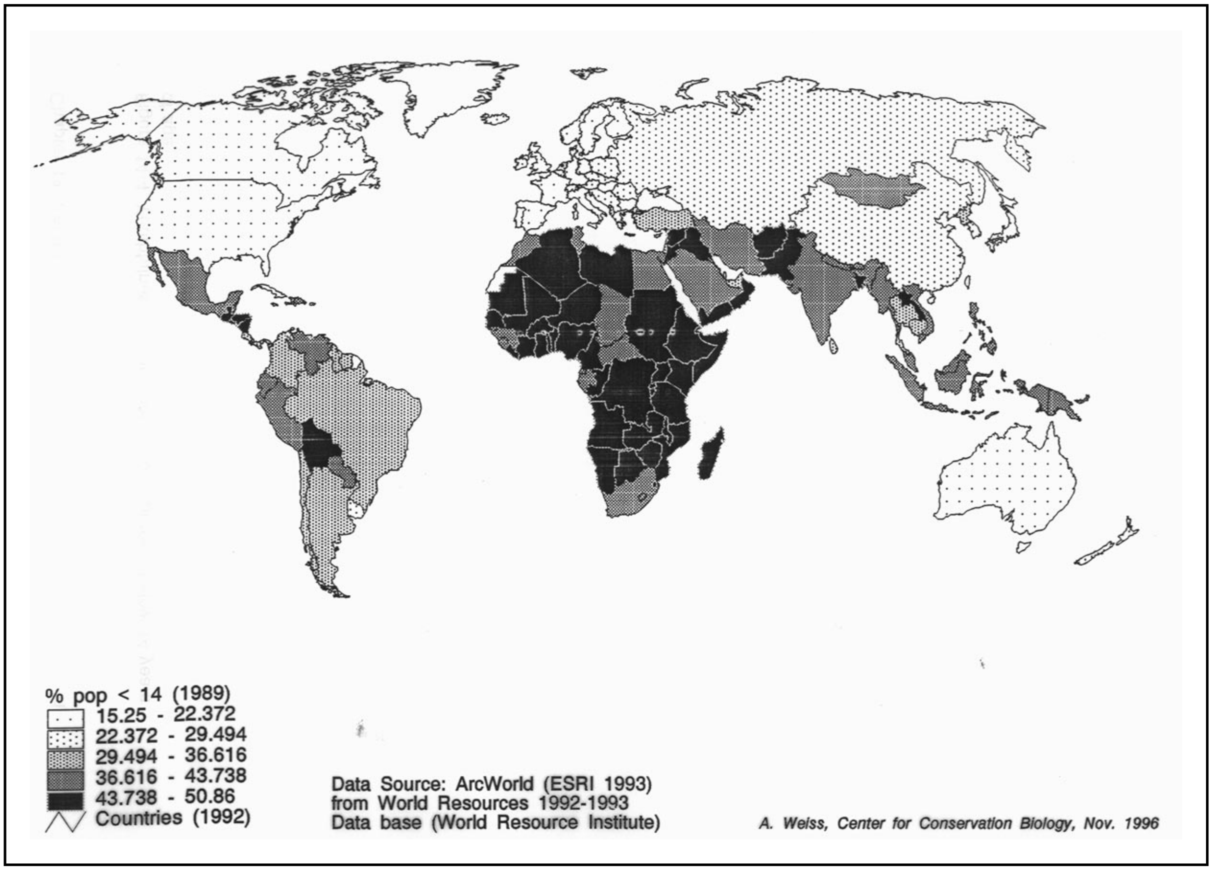


Figure 14-3. Youthfulness of world populations: percent below 14 years of age.

density, done in cells of about 100 square kilometers (km^2) for the Ganges-Brahmaputra delta. Developing nations like Bangladesh that have rapidly expanding populations, often with depleting resources, may be inherently unstable—and likely to confirm Cairncross' prophecy that "teenage populations are unlikely to be easy to negotiate with." Figure 14-3 displays the world in terms of what proportion of each national population is in the age range 0–14 years; youthfulness is not only a proxy for potential instability, but for rapid future growth due to "population momentum."

To specify the size, age, structure, and growth rate of a population and stop there is to leave out something obvious but important. The youthful nations in Figure 14-3 are also poor nations, with rapidly increasing needs from their environments that will accelerate the degradation of the latter.

Land cover change

A measure of that demand can be gotten from data on changes in the use to which land is being put, and the kind of vegetation that occurs on it. Indicators of the rates of land use and land cover change are not easy to obtain and to interpret. Satellite images are very useful, but often fail to indicate the finer structure of cover change; ground measurements are spotty, and thus even estimates of forest loss are subject to some variation.

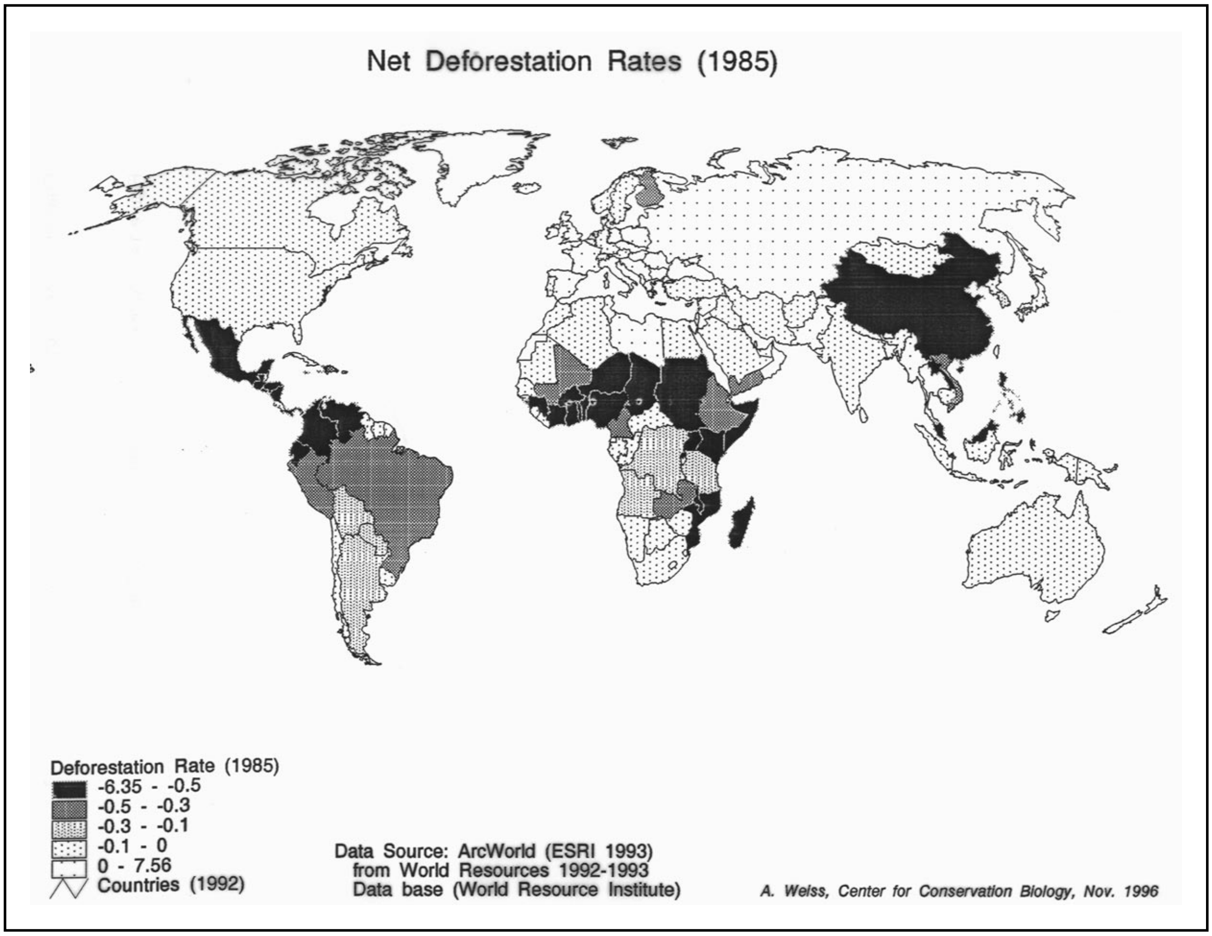


Figure 14-4. National net deforestation rates in 1985.

However, there is general agreement that the rates of loss of "closed forest" range between 0.5 and 1.5% per year. Figure 14-4 shows such estimates by nation for the year 1985 and demonstrates the concentration of high-loss nations in the developing world. From a broad environmental perspective, deforestation in the biologically rich nations of the tropics lower latitudes poses a potentially serious problem: the loss of biological diversity and of "ecosystem services." But in the more open dryland forests of other parts of the developing world, less dramatic loss of forests means that many of the world's two billion people who gather firewood for heating and cooking will have to travel farther and compete with others for what is left.

An equally meaningful geographic land variable would be soil quality. There is general agreement that in many parts of the world—particularly in the tropics, where soils are readily depleted because most nutrients are held at the surface, in living tissue—the quality and depth of soil has been significantly reduced. Beyond general estimates, it is difficult to obtain a regional picture of this important change in environmental quality.

The three variables critical to the support of poor rural people in the Third World are good water, good soil, and adequate wood. If they are lacking, troublesome consequences are likely to follow: the value of children as household assets may increase, stimulating accelerating population growth and launching a "vicious cycle" of environmental destruction; or mass movements of desperate people may generate conflict.

Climate change

Although there is general agreement that continued population growth and increasing per-capita energy demand will continue to add CO_2 and other "greenhouse gases" to the atmosphere, the degree of global warming is subject to debate because of the effects of aerosols, the feedback influence of increased cloud cover, and other uncertainties. A consensus view would put the average change due to a doubling of atmospheric CO_2—scheduled for late in the 21st century—at somewhere between 1 and 4 degrees Celsius.

Associated with this change will be a rise in average sea level (due to glacial melting and the thermal expansion of water) of a few tens of centimeters to one meter, and a possible increase in the intensity of violent storms. Global weather patterns, including monsoons, are notoriously sensitive, and their impacts on human welfare can be potent: for example, El Niño Southern Oscillation (ENSO) events can be correlated with maize yields in Africa and changes in precipitation in Central America, with significant outcomes for human health and welfare.

The populations affected by a rise in the average sea-level is shown in Table 14-1. Recalling Figure 14-2, which showed the high population density in the very low lying regions of the Brahmaputra-Ganges River deltas, suggests a likely location for massive population movements. Since this is also a region where monsoons regularly cause disastrous flooding, the influence of static sea-level rise is likely to be amplified by episodes of violent storms.

Climate change will also produce shifts in patterns of agricultural productivity for other reasons: CO_2 fertilization effects, increased temperature, altered patterns of precipitation, and alterations in growing season. The impacts of these changes on human populations, some of which are already apparent, and the resulting threats to security, are simply unpredictable at this point. But in general it is likely that the effects on agriculture in the poor countries, especially in the tropics, will be most severe—whereas the high-yield grain producing areas at high latitudes will be more able to adapt, and might even benefit. Thus

Table 14-1. Potential for population displacement by sea level rise.

Sea Level Rise	Population	Cumulative Population	Area affected (x 100 sq.km)	Cumulative Area
0 m	3,819,037	3,819,037	60	60
1 m	4,184,583	8,003,620	95	155
2 m	9,131,994	17,135,614	110	265
3 m	9,528,970	26,664,584	148	413
4 m	11,239,534	37,904,118	137	550
5 m	13,177,408	51,081,526	162	712

the likely impact of all climate-change prospects will enhance the already great disparity between the developed and the developing world.

Other possibly important changes include the effect of climate and population movements on infectious disease—both the pathogens themselves and their vectors. Traditional pathogens (malaria, cholera) are already shown to be influenced by climate change, and as people move into new, previously uninhabited areas, new infectious agents are likely to "emerge" (e.g. HIV, Marburg, Ebola).

Spatial relationships

Variables like environmental quality, population density, and income or other welfare indicators become more meaningful when their spatial configurations are clear. If, for example, rapidly growing populations of increasingly poor people are juxtaposed with affluent populations that have plenty of space and a more productive environment, there will be strong incentives for the former to move in the direction of the latter.

Rapidly industrializing nations often produce adverse transboundary effects on neighboring states, generating opportunities for interstate conflict. The development of a coal-powered industrial economy in China, for example, portends significant acid-rain deposition in the Korean peninsula and Japan. Pollution of inland or semi-enclosed seas, or over exploitation of common-property resources in them, could also lead to regional conflict.

Thus in trying to analyze environment/security relationships, border arrangements and regional differences in any of the relevant parameters are important. Under what circumstances might such tensions lead to conflict? I turn now to the important issue of political stability and conflict history.

Political variables

So far, I have been discussing the size and growth of human populations and the changes they have been exerting on the environment. Powerful forces are at work to enhance the probability of conflict: more people, fewer local resources, and degradation of those that remain.

But, of course, conflict requires more than misery. Plainly, peoples that have a history of fighting with one another are likely to do so again under the right circumstances. Where stable institutions are lacking and where religious or ethnic antipathy is high, the conditions are hospitable to trouble.

It is not easy to display these propensities in geographic form, nor is it immediately apparent what parameters one should choose. The plausible indicators of internal comity are many: they include a history of stable government, whether the nation is a democracy with a tradition of respect for human rights, the presence of strong civic associations, and literacy. Yet juxtaposed nations or peoples might rank reasonably well on some of these, but fight with one another because of traditional antipathies or resource needs.

We are trying to think through ways to represent these elements; at this time, the most tractable seems to involve the collection of expert opinion. Local and regional ranking for stability of political institutions, conflict history, and some indicator of ethnic or religious hostility should provide a way of integrating the geography of environmental and population stress with the sociopolitical variables.

Conclusion

Obviously this is a work in progress, and it entails a great deal of uncertainty. There is room for argument about almost every relationship and every parameter we have used. On the other hand, environmental pressures are mounting rapidly, and the prospect for unanticipated and tragic episodes mandates some boldness in trying to define an uncertain future.

It is important to add that the regional approach ignores some problems that may arise at a more global scale, as the result of major changes in climate or resource distribution. If it became obvious to a set of industrial nations that unchecked development elsewhere posed a major threat to the global environment, might they be tempted to halt it through military intervention? If it became obvious to a set of poor nations that the resource disparity facing them with respect to the industrial countries was unacceptable, might they be tempted to redress it through terrorism?

I have a personal concern that is less apocalyptic than either of the above—but is, in some ways, as troublesome. As the poor nations become poorer and their environments more impoverished, my fear is that local conflict will become irruptive—so much so that the best good will in the industrialized world will be unable to cope with it. The consequence will not only be a multiple disaster for the peoples in conflict; for the helpless observers in the rich nations it will be a relentlessly growing moral crisis. As we watch the collapse we will find ourselves caught between the impulse to give what we have and the desperate knowledge that it will not be enough. Survivor's guilt is not easy to live with. To avoid it, we simply must try to think this thing through, using whatever intelligence and imagination we can bring to the task.

China's environmental security: noncatastrophic perspective

Vaclav Smil

Offering seemingly plausible scenarios of environmentally induced socioeconomic decline, or even of a relatively sudden collapse, is not very difficult. The task is particularly easy in China's case: combination of the country's huge population, limited natural endowment and bold developmental aspirations makes the feeling that something will have to give virtually unavoidable.

Only one's imagination puts the limits on detailing grand causes and describing numerous particulars of environmentally induced destabilization in such a rapidly changing society. Perhaps the most extreme event that could affect China in the long run (but maybe as early as the first few decades of the 21st century) would be pronounced global warming resulting in a major shift of precipitation patterns. Reduced precipitation throughout already arid and semiarid northern China could desiccate the region to such an extent that mass outmigration could become the only practical solution. Changed intensity and distribution of monsoon rains in the south might have almost as profound socioeconomic effects.

Timing of such truly catastrophic events is unpredictable, and even if it could be predicted the changes themselves would remain unpreventable. In contrast, there are some anthropogenic environmental changes whose evident impacts are already causing a great deal of concern about their relatively near-term potential to seriously weaken, if not to derail, China's monumental quest for modernization. In order to assess them in some detail, I will focus on what I believe are currently the two most important environmental impacts that could imperil China's stability.

First, the greatest existential threat to the country's well-being would be posed by cumulative environmental degradation so extensive, and so severe, that it would seriously weaken the long-term capacity to feed the large, and in absolute terms still relatively fast-growing, population. This would have enormous repercussions both internally (as such a weakness would at least restrict the pace of China's modernization, and if it became entrenched it could be a source of widespread instability and a key factor leading to a profound political change) and externally (as the world grain market could find it difficult, if not impossible, to cope with a vastly increased demand, and as China would very likely become a large source of refugees).

Second, even if enough food could be produced, environmental pollution blanketing the new giant megalopolises and extending to the countryside could take an enormous toll. Initially, it would lead to rising levels of morbidity and mortality (both trends are already well documented in a number of Chinese cities). Eventually, it could cause acute air pollution episodes that could see large numbers of people dying prematurely and China's average life expectancy declining steadily. Or, summing up the two scenarios bluntly, could China's anthropogenic environmental changes lead to catastrophes due to starvation or pollution—or both?

I will assess each of these possibilities by describing the conditions now prevailing in China, by setting them into appropriate historical perspectives and comparing them with changes in other nations, and by looking at the extent of possible future deterioration and outlining some basic options for preempting, or at least moderating, undesirable shifts.

China's food production capacity

China of the late 1990s is a country enjoying unprecedented level of nutritional supply, in both quantitative and qualitative terms. Average per capita food availability is now over 2700 kilocalories (kcal) a day, nearly 15% above the Indian mean and only some 5% behind the Japanese rate.

The United Nations Food and Agriculture Organization, an institution prone to see food shortages rather than to point out comfortable supplies, concludes that this rate equals about 112% of food energy actually needed to cover the requirements of healthy and active life (FAO 1966). My calculations show that the food safety margin may be actually a bit larger, closer to 20% in 1995. Obviously, only a string of extraordinary natural catastrophes or a spell of monstrous mismanagement could alter this relatively comfortable situation in the short run.

This fairly comfortable position has been further strengthened by substantial qualitative improvements of average nutritional intakes. Official figures indicate that between 1980 and 1995 average annual per capita consumption of red meat almost tripled (to 35 kilograms [kg]), poultry supply (now at 7 kg) grew nearly ninefold, harvests of aquatic products (in 1995 just over 20 kg of mostly freshwater fish) rose about sixfold, and in 1995 Chinese ate six times as many eggs (about 14 kg) as 15 years ago. During the same period the retail supply of plant oils doubled (to almost 5 kg), that of sugar nearly doubled (to 7 kg), and consumption of liquors grew more than fourfold (to 15 kg).

Even when conservatively estimated, China's average per capita intake of animal foods is at least 20% higher than the global average. Given at least a modicum of sensible management, this relatively comfortable situation cannot deteriorate rapidly. Clearly, China's current meat and egg intake represents a substantial grain reserve that could be tapped in times of a food crisis.

Reducing animal food intake would not be welcome by Chinese consumers eager to buy more of these foodstuffs—but it would present no nutritional hardship as healthy diets resulting in low infant mortalities, low morbidities, active life, and long life expectancies are quite compatible with even much lower levels of animal food consumption.

But reducing the annual per capita demand of animal foods from about 40 to just 20 kg would release land currently devoted to feed production that could yield at least 60 million metric tons (t) of food grain. This mass is about three times as large as China's record grain imports in 1995. Faced with either shortages of grain on the world market or with too high a price of food imports, China clearly could, within a year, produce enough food grain to ride out any short-term crises.

Seen in a longer perspective, 60 million t of grain would be also sufficient to supply staple cereals for at least 200 million people at the current level of average food intakes. That population total is equal to the cumulative increase anticipated during the next 15-17 years. Again, this shows that even if China is unable to raise its food productivity (an unrealistic assumption indeed!) it could avoid any acute food crisis during the next 10-15 years by adjusting the food/feed grain ratio, a shift many societies undertook during times of crises.

I will argue that—with the exception of a climate change of unprecedented rapidity and extent—no plausible combination of environmental problems can fundamentally reverse this relatively comfortable situation in the short run (5-10 years), and China's food output can continue growing throughout the next 20-25 years.

These conclusions can be made because none of the five most important degradative processes affecting crop production—natural catastrophes, loss of farmland, declining soil quality, lowered water availability, and higher levels of pollution—has reached a stage where yield declines are inevitable, and because a combination of already available, and steadily improving, management options can moderate, neutralize, or eliminate virtually all undesirable environmental changes.

Natural catastrophes would have to be of unprecedented magnitude to change this outlook. Floods and droughts that cause some reduction of normal crop yields affect between 15 to 25 million hectares (ha) of the country's farmland every year (or as much as one-fifth of all cropped land), but these recurrent disasters have not prevented a steady rise in overall production (State Statistical Bureau 1995). Indeed, the 1995 record harvest of 466 Mt of grain was achieved in spite of extensive summer flooding, and another record harvest was brought in in 1996 in spite of the Yangzi basin floods that rank among the worst during the past two generations (Crook 1996).

China's farmland is not limited to 95 million ha officially claimed by the State Statistical Bureau: the real figure is between 120 and 150 million ha, which means that the country's 1995 per capita arable land availability is at least at, or slightly above, 0.1 ha (Smil 1993; Crook 1993; Wang et al. 1992). This rate is no less than 2.5 times as high as in Japan or Taiwan, and twice as large as in South Korea (USDA 1996). Clearly, China is not as land-short as these two nations with which its future food supply situation is so commonly compared.

This reality also means that most of China's official crop yield figures are wrong. Prorating the officially reported harvests over larger areas of farmland would make the smallest difference for rice yields (as paddy land is not widely under-reported) and the largest difference for corn which may be grown in some provinces on areas 20-40% larger than officially acknowledged. China has thus considerably more room to improve the yields of this key feed grain (Crook and Colby 1996).

Even when assuming that the recent high net rate of farmland losses, averaging around 500,000 ha a year, would continue during the next generation, the country would still have at least around 110 million ha of farmland by the year 2020. Combined with a high population projection of 1.5 billion people this would give China per capita availability of 0.07 ha, just slightly worse than the official 1995 mean, and still almost twice as much as today's Japan.

Even with the total area unchanged, severe qualitative deterioration could appreciably diminish the extent of farmland capable of producing high yields. Undoubtedly, China's soil erosion and salinization have been excessive in a number of regions, the former mainly throughout the north and the northwest, the latter above all in Jiangsu, Anhui, Shandong, and Hebei. Recent retreat from cultivation of green manures and declining amounts of organic wastes in periurban regions (due to a widespread construction of urban sewers) have contributed to the lowering of organic matter content in some soils.

But these changes are not harbingers of imminent production decline. We have come to realize that declines in soil quality—difficult to quantify in the first place, mainly because of a limited amount of historically comparable information—have usually produced only gradual, and marginal, effects on yields, and that they can be controlled, and reversed, by appropriate agronomic practices even in the most vulnerable areas (Crosson and Anderson 1992).

Indeed, a recent comparative study of China's soil quality does not show any worrisome large-scale decline between the 1940s and the 1980s (Lindert 1996). Similarly, an evaluation of environmental degradation on cereal crop yields indicates a noticeable, but a fairly marginal loss amounting to about 6 million t a year during the late 1980s, and equivalent of less than 1.5% of annual grain harvest (Huang and Rozelle 1995).

China's water shortages, above all throughout the North China Plain and in the arid north and northwest, have been widely reported in local and national press, and linear extrapolations of demand foresee some very serious bottlenecks developing within a decade or two. While the current shortages are real, the reasons for them must be ascribed primarily to China's irrational management of water rather than to the rapidly approaching limits on actual water withdrawals.

China of the 1990s is withdrawing its available water at a lower percentage rate than India, but it has been doing so in an extraordinarily wasteful manner. Irrigated crops with high water requirements are often grown in inappropriate settings (there is surely no need to grow rice in Beijing's suburbs), typical irrigation techniques have low field efficiencies (often below 30%), and water is available to farmers at a small fraction (as low as one-tenth) of its actual cost.

Urban and industrial waste water treatment and recycling are highly inadequate (nationwide less than a quarter of industrial wastewater is treated to reach acceptable standards). Gradual improvement of these deficiencies holds considerable promise for increasing effective water supply throughout semiarid and arid northern provinces even without resorting to any massive south-north water transfers.

Considerable Western experience with effects of classical smog, arising from combination of sulfur dioxide (SO_2) and suspended particulate matter, on crop yields shows only a limited damage whose impacts is usually masked by rising productivity (NAPAP 1991). Recent assessments for China echo those realities. Total damages caused to China's crops by air pollution have been estimated at between 2 to 7 billion yuan a year (Smil 1996; Xia 1996). While locally crippling, and regionally important, these damages represent only about 1% of the total value of crops produced annually in the country during the early 1990s.

At the same time, some pollutants have actually a beneficial impact. Switching to ammonia and urea from previously common ammonium sulfates led to growing sulfur deficiencies, especially in soils producing such high-protein crops as soybeans; signs of the same problem have been also noted in China, and atmospheric sulfate deposition helps to moderate that shortage.

Photochemical smog, with its high levels of ozone, an aggressive oxidant harmful to many plant tissues, appears to be a more serious matter. Depending on the assumed level of natural ozone concentrations, annual economic effects of ozone pollution on eight sensitive U.S. crops was put at roughly $1-3 billion a year during the late 1980s, or as much as 6% of the total harvested value (NAPAP 1991). In spite of some high local ozone levels and spreading extent of photochemical smog, both the typical concentrations and affected areas in China are still below the U.S. rates. As tropospheric ozone levels rise throughout China, so will the damage to sensitive crops.

Obviously, none of these damages are going to triple or quintuple within the next few years; even without any air pollution controls they would rise along with higher emissions, growing no more than 5-8% a year; that is, doubling in 9-14 years.

At this point, I hasten to add that I am not dismissing either the continuing loss of China's cropland or problems with its quality, and that I am not trying to trivialize current damages due to air pollution (those caused by water pollution have been estimated to be much lower than for smog). I am merely pointing out the actual current state of affairs and realistically projecting the impacts of further deterioration. As with any ecological assessment, time spans make the critical difference.

Given just a modicum of sensible management, environmental changes affecting China's food production cannot seriously weaken the country's capacity to feed itself during the next 5-10 years. Adequate investment in agricultural research, a rising quality of farm inputs, and higher efficiency of field production and animal feeding—measures not calling for any revolutionary advances but demanding sustained attention—would help to assure that the outlook for the following 10-15 years could continue to be fairly comfortable.

In contrast, relative neglect of agricultural sector and a slow progress in remedying such critical environmental factors as shortages of irrigation water (a more realistic pricing could be of immense help) or rising levels of photochemical smog (impossible without better transportation policies) could mean that the second decade of the next century could be a period of rising concerns about China's long-term capacity to feed itself.

Intolerable environmental pollution

I will illustrate the realities and the options within this wide-ranging category of problems by focusing on the most obvious form of China's pollution, the dismal quality of its urban air. Genesis of this problem is in China's extraordinarily high dependence on coal: for decades that fuel has supplied more than 70% of all primary energy consumption, a share now unparalleled in any other nation. Moreover, the post-1980 economic expansion made China both the world's largest producer and consumer of coal.

Most of the fuel is still burned without any previous cleaning in relatively inefficient medium- and small-sized boilers and in tens of millions of household coal stoves. Inevitably, emissions of total suspended particulates (TSP) and sulfur dioxide have gone up. Official statistics put TSP emissions at about 15 million t (State Statistical Bureau 1995). According to the same source, SO_2 releases rose from some 12 million t in 1980 to about 19 million t in 1995, but some prominent Chinese atmospheric scientists believe that the total may be up to 15% higher.

Concentrations of these pollutants in China's large cities frequently surpass the nation's hygienic norms, with peaks being an order of magnitude above the permissible limits. China's ambient air quality standards set the allowable annual average of SO_2 at no more than 60 micrograms of SO_2 per cubic meter of air (60 $\mu g/m^3$), and the highest 24-hour concentration at 150 $\mu g/m^3$, requirements stricter than in the United States, where the two values are, respectively, 80 and 365 $\mu g/m^3$.

Not surprisingly, these maxima are commonly exceeded in all of China's large urban areas. Even Beijing's cleanest residential areas average between 80-100 $\mu g/m^3$, mean annual levels in the most polluted northern cities are commonly twice the allowable level, daily maxima are often above 300 $\mu g/m^3$, and short-term winter peaks go above one $\mu g/m^3$ (Smil 1996).

In contrast, today's mean SO_2 levels in North American cities are commonly below 20 $\mu g/m^3$, and even the Tokyo megalopolis averages just 30 $\mu g/m^3$ (U.S. Department of Commerce 1995; Environment Agency 1995). But while Chinese ground concentrations are considerably higher than in any affluent country, they are very much like the levels that were common in most urban and industrial areas of rich nations as recently as the mid-1960s.

At that time Japanese mean of SO_2 in urban areas was 150 $\mu g/m^3$, and concentrations above 100 $\mu g/m^3$ were not unusual in large cities of America's Midwest and Northeast. And these high levels had prevailed during winter months in parts of central Europe even during the 1980s, and in some locales still in the early 1990s.

China's total SO_2 emissions and their density are not unprecedented either. Total U.S. SO_2 emissions of about 19.5 million t in 1995 are still about as large as China's total, which means that in per capita terms they are at least 4.5 times larger. Emission density provides a more environmentally meaningful comparison: American SO_2 emissions in states with the highest concentration of large coal-fired power plants (Ohio, Pennsylvania, Kentucky, Tennessee) average between 10-20 t SO_2/km^2, and the highest European national means are very similar. In contrast, during the first half of the 1990s Chinese SO_2 emissions in the largest coal-burning provinces of north and east China (Liaoning, Hebei, Henan, Shanxi, Shandong, and Jiangsu) prorated to between 5-9 t SO_2/km^2 (Smil 1993; Smil 1996).

Two reasons explain why North American and European ground-level concentrations are not as high as in China: most SO_2 emissions are released from tall stacks of large power plants and their mixing into large volume of the lower troposphere reduce the ground concentrations; in the United States more than half of large coal-fired power plants are equipped with flue gas desulfurization.

But just 30-40 years ago the Western short-term maxima encountered during unfavorable weather conditions had repeatedly reached levels that resulted in significant increases of excess mortality. During the episode of heavy air pollution in London in early December 1952 average levels of SO_2 stayed above 1000 $\mu g/m^3$ for four consecutive days (Brimblecombe 1987). And during the Thanksgiving 1966 episode in the eastern United States, the highest daily mean of SO_2 in New York surpassed 1300 $\mu g/m^3$, and concentrations of the gas remained above 500 $\mu g/m^3$ for six consecutive days (Fennsterstock and Fankhauser 1968).

Such exceptional air pollution episodes were associated with temporarily increased mortality among the most vulnerable groups of exposed populations (above all elderly people with respiratory and cardiovascular ailments): London smog of December 1952 was credited with some 4000 premature deaths. Cleaner fuels and air pollution controls prevented further occurrence of such high air pollution episodes, and the subsequent chronic exposures to lower concentrations of SO_2 and TSP have much more subtle effects that have not been easy to quantify.

Decades of intensive research interest into the effects of SO_2 and TSP on human health have found significant statistical relationships with higher frequency of upper respiratory infections, with increased incidence of chronic obstructive lung diseases (bronchitis, asthma) and with lung cancer. Chronic exposures to relatively high levels of urban air pollution have thus obviously contributed to the changing patterns of morbidity and mortality—but they could not prevent the continuing rise of life expectancy throughout the rich world.

The very same experience is being repeated in China. As expected, we are seeing higher incidence of chronic obstructive pulmonary diseases (they now account for about a quarter of all deaths, and their rate is at least four times higher than in the United States). But correlating these changes to outdoor air pollution is complicated by China's extraordinarily high rates of smoking and by often very high levels of indoor air pollution from improperly vented stoves. Indeed, this latter factor may be as large, or even a larger, contributing factor (Smith and Liu 1994).

In any case, Chinese life expectancy has shown a steadily, and impressively, rising trend, increasing from less than 60 years in the mid-1960s to just over 70 years in 1995, with two additional years added since the beginning of Deng's reforms in 1980 (State Statistical Bureau 1995; United Nations 1995). Declines in infant mortality have accounted for most of this gain: health impact of worsening pollution problems should be felt first among the most sensitive groups of the affected population—but China's infant mortality fell by nearly a third between 1980 and 1995, to just below 30, giving the country a lower rate than the mean for the world's middle income nations (United Nations 1995).

Clearly, it is difficult to argue on the basis of this evidence that air pollution is undermining the well-being of China's population to such an extent that it could soon lead to massive health crises whose impact could become a notable destabilizing factor in the country's developmental aspirations. At the same time it must be appreciated that the Chinese are already doing more about the problem than the affluent nations had done at a comparable stage during their modernization.

Exploring this evolution using official exchange rates is not appropriate because they are highly misleading. Indeed, even the preferable assessments in terms of the purchasing power parity (PPP) remain just good approximations rather than accurate valuations. There is now a growing consensus, for example, that the earlier PPP calculations, putting China's per capita gross domestic product (GDP) at close to $3000 in the early 1990s, were exaggerations, and that China's 1995 per capita GDP did not surpass $2000 (World Bank 1996).

Yet nearly a decade ago this still decidedly low-income society had established a National Environmental Protection Agency (NEPA). It has adopted a variety of environmental quality standards and it has set up a system for enforcing its new anti-pollution regulations. Not surprisingly, NEPA is underfunded, most standards are commonly violated, and enforcement is haphazard at best.

At the same time, one must remember that rich countries began to pay serious attention to environmental degradation in general, and to air pollution in particular, only when their per capita GDPs were considerably higher than in China of the early

1990s. Britain enacted its first anti-air pollution law in 1955, and the United States only in 1971, when the country's per capita GDP was over $18,000 (in 1995 dollars).

Even more fundamentally, China has been increasing its overall energy-use efficiency faster than any other nation during a comparable stage of its modernization (Smil 1993). Long-term declines in primary energy consumption per unit of GDP have been impressive throughout the Western world during the 20th century—but the recent Chinese improvements have been even faster.

China's mean energy intensity was about 0.7 kilograms of coal equivalent (kgce) per constant (1980) yuan of GDP; by 1990 the rate declined to 0.42 kgce/yuan, and in 1995 it was slightly below 0.35 kgce/yuan, or a bit less than half the value 15 years ago. Consequently, if China's energy/GDP ratio were to remain at the 1980 level, the country's 1995 primary energy use would have been twice as large, and because the structure of primary energy use has changed so little, the resulting emissions would have grown by the same factor.

Further reductions of China's SO_2 and TSP air pollution will come as the country's fuel consumption gets transformed according to a universal pattern of primary energy use. A rising share of bituminous coal is burnt in large, modern electricity-generating stations, where efficient electrostatic precipitators remove more than 98% of all fly ash, and where SO_2 emissions are scrubbed and/or dispersed from tall stacks higher into the troposphere and transported over longer distances, preventing a build-up of excessive ground-level concentrations.

Of course, once oxidized, these SO_2 emissions become the principal ingredient of acidifying deposition, but dry north China, where most of the new large coal-fired plants will be located, has a naturally high levels of airborne alkaline cations in dust whose presence can keep the pH of the region's rain above the level harmful to most biota. Rainy south China, whose coals also have higher sulfur content, does not enjoy that advantage, and further expansion of the area affected by acid precipitation south of the Yangzi is thus inevitable.

We have a great deal of European and North American experience with this phenomenon, and thus can reasonably conclude that acid deposition would be a most unlikely source of environmental degradation leading to socioeconomic destabilization. While potentially costly—above all in terms of its impact on materials, and on sensitive waters and biota—acid deposition is a manageable environmental deterioration, whose effects can be moderated, and eventually reversed, with a combination of liming, flue gas desulfurization and switching to cleaner fuels. Undoubtedly, during the next generation China will be moving, albeit slowly, in all of these directions.

In addition to SO_2-TSP pollution, recent rapid multiplication of passenger cars and trucks, and growing emissions of thermal NO_x from large power plants, have been responsible for no less objectionable and potentially no less damaging episodes of heavy photochemical (Los Angeles-type) smog. Our experience clearly shows that as long as car ownership and electricity generation expands rapidly, this form of pollution is much more difficult to control.

However, as already noted, effects of photochemical smog on crop yields will remain in the realm of regrettable marginal losses, rather than in the category of drastic reductions. And the experience with high NO_x and O_3 levels in the modernizing world's megacities—ranging from Cairo and Tehran in the Middle East to Bangkok and

Taipei in Asia—demonstrates that photochemical is a highly objectionable form of pollution, obviously harmful to many sensitive individuals, but, in the final benefit-cost analysis, a condition tolerated by millions of urban dwellers unwilling to give up their cars—and hence hardly a matter of imminent socioeconomic destabilization.

Realities and concerns

China, much as any other large and rapidly modernizing nation, is already paying a substantial price for its serious environmental degradation. Increasing attention to these changes—most notably, the total investment in environmental protection in the year 2000 is to be double the 1995 sum—will bring some improvements, but the combination of continuing population and economic growth makes it almost certain that the overall state of China's environment is not going to improve radically during the coming generation. But these costly, and individually painful, or even crippling, realities must be seen in proper historical perspective, and they must be weighed against further improvements in the overall quality of life.

Viewed in these contexts, there is little doubt that China's environmental degradation will continue to be an economic burden and a social aggravation but that, taken alone, it will not derail the country from its path of modernization, nor will it precipitate any worrisome destabilization of Chinese society during the next ten to twenty years.

When looking beyond that time horizon it is much easier to make a case for more serious concern about the state of China's environment—but also for unpredictable changes that may fundamentally alter today's speculations. After all, 25 years ago even the most astute China watchers could not have predicted any of the key features of today's China. At that time the country was still in the midst of Maoist madness, cruelly mislabeled as the Cultural Revolution; it was merely a decade since the end of history's greatest man-made famine that claimed 30 million lives; all food was rationed at levels no better than 15-20 years earlier; economically, the country was an isolated, Stalinist autarchy; there were no Chinese students abroad, and no foreign investors inside.

Today's contrasts with those quarter-century old realities are truly astonishing. Changes that took place since the early 1970s obviously contributed to further degradation of China's environment—but, for the first time in the country's long history, they also laid foundations for decent quality of life for most of its people. And the historical experience demonstrates that only after reaching that developmental stage will a nation turn more of its attention to the state of its environment and embark on a difficult quest of reconciling human well-being with the preservation of biospheric integrity.

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Former Soviet Union's environmental and health problems

Murray Feshbach

Let me begin by making some slightly long introductory comments that will provide the context for the specifics of the "case study" at hand. Most basically, I use a broad definition of "environmental security' when asking, "Does it matter to the United States or to our allies?" The evolution of U.S. policy in this area thus does not surprise me. The spread of concerns about environmental security has led not only to new statements of purpose and activities by the Department of State, the Department of Defense, the United States Agency for International Development and others. (See, for example, the new 1996 U.S. National Security Strategy document issued by the White House in January of 1996, relevant portions of which are reprinted in the Appendix.) It has also resulted in the formation of an Environmental Security Workshop at the Woodrow Wilson International Center for Scholars of the Smithsonian Institution in Washington D.C., under the directorship of P.J. Simmons, and to new publications, such as a new journal called (not surprisingly) *Environment & Security*. In the unofficial "propaganda" for the journal aimed toward new subscribers, the editors cite "The ending of the Cold War era [which] has provided the occasion for a reassessment of the meaning of security in the national and international contexts. . ." In particular, they stress the potential consequences of environmental impacts such as ozone depletion, climate change, deforestation, desertification, the decline of ocean fisheries, and loss of biodiversity in the context of continuing population growth. If these were not enough of an agenda for the journal, they add "These changes give rise to new security concerns for they pose a direct threat to the welfare of human societies and can contribute to conflicts and violence within and among states."

Turning to the specifics, it is to me not surprising given the past Cold War relationship between the former Soviet Union (FSU) and the United States that this region has been a focus of attention as the environmental security concept evolves. Consider, for example, Secretary of State Warren Christopher's speech, at Stanford University on April 9, 1996, with the formal title of "American Diplomacy & the Global Environmental Challenges of the 21st century," reprinted in the Appendix. The secretary made clear, after first addressing global issues, that in the regional context: "There can be no doubt that building stable market democracies in the former Soviet Union and Central Europe will reinforce our own security. However, for these new nations to succeed, we must help them overcome the poisonous factories, soot-filled skies and ruined rivers that are one of the bitter legacies of communism. The experience of this region demonstrates that governments that abuse their citizens too often have a similar contempt for the environment."

Continuing, Secretary Christopher commented that "Russia and China are both confronting major environmental problems that will have *a profound effect on their future—and on ours."* (emphasis added)

A similar concern with this critical region appears in the Memorandum of Understanding (MOU) among the Environmental Protection Agency, the Department of Energy, and the Department of State. Concerning Cooperation in Environmental Security, reprinted in the Appendix. This MOU was designed "to enhance environmental cooperation between the United States and foreign partners, including the Baltic States, Russia, Eastern Europe, other states of the FSU, and Asia–Pacific nations through information exchange, research and development, technology demonstration and transfer, regulatory reform, emergency response training, and environmental management."

Nor is this interest in the FSU limited to the United States. The environmental minister of the European Union, Mrs. Ritt Bjerregaard of Denmark, in September of 1996, stipulated that Central European countries will not be admitted to the European Union until they take on their environmental problems more vigorously. They must bring many laws, standards, and rules into line with those of Western Europe, incorporating into national law over 200 European environmental-related directives (Simons 1996). It may be a long time before they become full members—but at least the line has been drawn as to what is necessary, and even more so, hopefully attended to as required.

With this as background, let us now turn to the specifics of the discussion at hand. There are a myriad of problems affecting the FSU, and potentially its neighbors and the United States. While I will discuss each separately, the reader should remember that all of these occur together, and are all linked. In fact, it is their synergistic impact that is so devastating, and makes the FSU such a daunting case study.

<u>Air pollution</u>. In terms of air pollution, the emission of solid particulates, sulfur dioxide, and nitrogen oxide pose the greatest region-wide environmental security problems (i.e., for all of Central Europe and the FSU). Discharges, especially of sulfur dioxide, from Central European sources are the highest in Europe. We have a prime example from the Norwegian experience. The Norwegian Greens proposed literally "bombing" plants in the Nikel' region due to dangerous potential hazards from transborder windblown effects, which it was feared could cause in Norway low life expectancy similar to those of workers (34 in Nikel') and of residents of the city (44 years of average life expectancy at birth) at the height of production. Atmospheric pollution from the nonferrous metallurgical kombinats "Severonickel" and "Pechenganickel" on Kola Peninsula also has serious implications for northern Europe, Finland as well as Norway (WHO 1996, p. 2-4). Particulate emissions in l991 reached 15.4 thousand tons from the Severonickel plant and 6.0 thousand tons from Pechenganickel. Sulfur dioxide emissions for this same year were measured at 257.5 thousand tons from Severonickel and 195.7 thousand tons from Pechenganickel (Yablokov, p. 25).

Acid rain is thus a major issue in this region. While the overall average in Russia and Ukraine is no higher than in West Germany and Sweden,[1] there are many locations where emissions from specific plants and facilities is so great that the forests in the given regions are totally dead. Forests within a 20-kilometer radius of Monchegorsk, site of the Severonickel' Combine, are reported to be completely dead. Norilsk Nickel Combine in Siberia on the Taymyr Peninsula is the source of destruction of over 2.5 million hectares (over 5 million acres) of the surrounding tundra and forest-tundra land. Countries affected by acid rain originating in Russia include not only Norway, but also

Kazakstan, Finland, Ukraine, Belarus, and Sweden (Audritsh 1993, p. 13).

It is not only acid rain that affects flora. The fall-out of heptyl in the Plesetsk testing range area has killed vast areas of fauna as well as flora. I understand that an American process is being used to detoxify the stocks of this liquid rocket fuel—but given the size of the stock, it may take quite a while. Again this largely affects Russia, but when the Baltic states took control of their countries there were several incidents where the local governments refused—because of the danger of this supertoxic, nerve-paralyzing, carcinogenic, and volatile material—to move into military sites where heptyl had not been withdrawn by the Russian military .

<u>Water pollution.</u> When one is concerned about societal stability and the underlying health of a population, water quality is of major importance. As a vector of disease, poor water quality is responsible for many illnesses. With 75% of all surface water in Russia, as well as Ukraine and other areas still polluted (as it has been for many years now), and perhaps getting worse in quality, then this could well contribute to the evaluation of UNICEF several years ago that Russia faces the potential for "social disintegration." Among many examples of the pollution of the waters, one major incident occurred when a polymer plant in Belarus accidentally discharged tons of an organic cyanide compound into the Daugava River in 1990, leading to a massive fish kill in Latvia. The Dniester River was further contaminated through excessive pesticide use in Ukraine and Moldova (Yablokov, p. 17). Other pollutants, including heavy metals such as lead, cadmium, mercury, and vanadium are at much higher levels than in the EEC.

Another example occurred near Arkhangel'sk, where the population has become endangered when a plant decided to clean its pipes and discharged 16 tons, not kilograms, of mercury into the Northern Dvina River. This travesty hardly received any attention, certainly in comparison to the Usinsk oil spill, but it is only one of some 700 such accidents every year. These not only affect local regions in the FSU, but also are a danger to the United States and/or its allies through their penetration into the Arctic Ocean through the rivers emptying into this ocean. More than 53% of the organic wastes in the Baltic Sea comes from Poland, former East Germany, and the FSU (Audritsh 1993, p. 15).

Environmental pollution by DDT and related compounds such as polychlorinated biphenyls, dioxins, and polyaromatic hydrocarbons, seem to be mostly a local, albeit very serious problem. (DDT, by the way, was produced in the FSU until at least 1989.) It probably does not pose an immediate ecological threat to Europe (Audritsh 1993, p. 15) or nearby Asian countries, but it should be noted that such persistent chlorinated compounds are found throughout the Arctic.

The contribution of polluted water to disease is also a concern. Such water was a significant contributor to the spread of cholera recently at quite a high level in Ukraine, less so in Russia, but potentially high again unless internal bodies of water are cleaned up. Such outbreaks have international dimensions; cholera outbreaks have spread from Russia and Ukraine to other eastern European countries, and, according to the World Health Organization, to Finland, Poland, and Turkey (Galazka, Robertson, and Oblapenko 1995). The prognosis for an improvement in the cholera situation remain unfavorable due to the activization of epidemic processes and the constant risk of the infection being imported to any country of the world (Onishchenko et al 1994, pp. 34-

39). Recently, the border from Mongolia to Russia was closed due to an outbreak of cholera in Mongolia.

The seas. The relationship between oceans and the environment has long been recognized. For example, the United Nations Convention on the Law of the Sea provides for the rights of coastal states to control activities in adjacent, offshore areas to protect their economic, security, and environmental interests. Consider in this regard the Arctic Ocean. The Arctic region is a virtual laboratory that can give "early warning" of environmental damage. Thus, the newly established European Environment Agency is paying particular attention to this because of the concern of its member states, and wariness that the currents in the ocean will bring additional pollution dangers from previous Russian dumping to its member states (Yablokov, p. 22).

U.S. concern is mostly manifested in the issues related to nuclear submarine dismantlement and to the dumping of nuclear submarines with nuclear reactors and fuel rods still intact, as well as undersea nuclear waste dumping sites that might affect the Norwegian, Barents and Kara Seas (Europe's Environment 1996). Very recently, in fact, international reaction and fear has been sufficient to lead to an agreement by the United States and Norway to provide technical and financial aid to help Russia dispose of nuclear submarine reactors and other radioactive waste. The Norwegians have a compelling reason to fear nuclear accidents on land and in the sea, as well as potential destruction of their fishing zones (Audritsh 1993, p. 16).

This latter point, as well as concern for the health of Alaskan citizens impelled Senator Stevens of Alaska to have the late, lamented Office of Technology Assessment prepare a major report on the potential danger to Alaska. While that report found no clear and present danger, it did not exclude future problems. However, the research of Dr. Ted de Laca at the University of Alaska, Fairbanks, indicates that major sources of potential danger were not incorporated in the estimates for radioactivity emanating from Russian sources in the form of major river estuaries containing radioactivity from internal sites transiting through the rivers to the Laptev Sea in particular—whose currents are more directly transporting contaminants toward Alaska and other Pacific Rim countries. In addition, the work of Dr. Dan Jaffe, another faculty member who is building wind direction models, shows that possible nuclear power station accidents at, for example, Bilibino would impact Alaska in four days (based on a number of models and assumptions). It thus behooves the United States and other interested governments to expand their activities in the realm of nuclear safety and remediation of existing contamination in the Arctic region as well as elsewhere.

There are also problems regarding the Baltic Sea. For one thing, it contains increasing concentrations of mercury, cadmium, lead, nitrogen compounds, petroleum products, detergents, and organic wastes as a result of dumping activities (NY Times 1996, A12). Equally important environmentally are the dangers emanating in and from this sea as a result of the large amount of chemical weapons which were dumped in the post–World War II period. Between 100,000 and 300,000 tons of poisonous compounds, mainly sarin and mustard gas, were disposed of at a depth of a few dozen meters (NY Times 1996, pp. 16-17). Undoubtedly even more of a danger to the ten littoral countries of the Baltic Sea is the earthen dam containing nuclear wastes at a site in Sillamae, Estonia. This dam is separated from the Gulf of Finland leading to the Baltic Sea only by

10 meters. The United States and/or its allies should at the minimum spray concrete on the dam perimeter. In mid-September of this year, the Estonian government finally allocated in local currency, 4.8 million kroons ($400,000) to seal the banks of the lake, but this amount is far short of the one billion kroons ($83 million) estimated by Mr. Bjerregaard to be the necessary level of expenditure (Boreyko 1994, p. 3). Perhaps the fact that the Helcom Commission's research found that there is no clear and present danger here as well reduces the concern of the U.S. government, but not mine.

The Black Sea has been polluted by eastern Europe. For example, pollution from the Danube alone contributed 60,000 tons of phosphorus, 340,000 tons of nitrogen, 1000 tons of chromium, 900 tons of copper, 60 tons of mercury, 4500 tons of lead, and 50,000 tons of oil each year annually (EcoNews 1996, p. 18). Additionally, a number of rivers from Ukraine and Russia contributed substantial but unmeasured mercury, cadmium, lead, nitrogen compounds, petroleum products, detergents, and organic wastes (Pomfret 1994). There even are reports of nuclear waste being dumped by the Soviets into this sea as well as the Arctic seas. Adding to the problem is the fact that there were ten major oil spills in the mid-1980s alone affecting this sea (Pomfret 1994, p. 17).

Hydrogen sulfide is another potentially serious problem in the Black Sea, not only for the former Soviet Union, but also for other countries such as Bulgaria and Turkey. Its toxicity is such that a five minute exposure to 800 parts per million (ppm) has resulted in death; inhalation of 1000-2000 ppm may cause coma after a single breath. It is flammable in the air, and its combustion products (sulfur oxides) are also toxic by inhalation (Boreyko 1994). Thus its presence in the Black Sea is a genuine concern, but not sufficiently recognized in my opinion by various domestic and international governmental agencies so far. This is not to say that nothing has been done, but that so far most of the activity is scientific tourism. The water is heavily saturated with hydrogen sulfide 100 meters below surface (the level where oxygen runs out [The oxygen-less zone is now more than 15,000 square miles, about one-tenth of the total area] (HHMI 1996). Since the late 1970s, the boundary of water poisoned by hydrogen sulfide has risen from depth of 200 meters to 50-85 meters, (AFP 1992) rising to the surface at a rate of 2 meters per year (according to joint American-Turkish survey in 1988) (Vinogradov 1988, p. 42). If the gas reaches the surface, an explosion might be triggered that could destroy all living creatures in the sea and kill hundreds of thousands of inhabitants of the former Soviet region, Turkey, and the former east European countries bordering the sea (Vinogradov 1988, p. 46). Yablokov, the former environmental advisor to President Yeltsin, has warned that it could bring unprecedented scale of injection of hydrogen sulfide to significant territories of Turkey, Rumania, Bulgaria, Ukraine, Russia, and Georgia (Vinogradov 1988). As in other cases, there is some but not much talk; even less is being done to reduce this danger to themselves and other countries.

As in the case of the Baltic Sea, in addition to these pollutants, ammunition was systematically dumped by Soviet military authorities into the Black Sea without permission from Ukraine's environmental agencies. Reportedly, for example, poisonous chemical weapon compounds (mainly mustard gas) were dumped at a depth of only 50 meters (Yablokov, p. 24).

The Sea of Japan offers additional examples. Mustard gas was dumped at a depth of 1 km not far from Vladivostok in 1941;[2] expired ammunition was dumped in the Aniv gulf near Sakhalin Island, in July of 1995 (Boreyko 1994, p. 16). As in other areas, nuclear dumping occurred here; more than 144,000 cubic meters of nuclear waste was dumped in the East Sea near Kamchatka between 1966 and 1992 (Belovitskiy 1995, 55). More prosaic wastes are also a problem: only 3% of Vladivostok discharges are currently processed in the city's underdeveloped purification system (YONHAP 1993). Whether these pollution events will affect Japan is not known; but it should be noted that it is unlikely given the hydrolyzing effect of water movements in the sea area.

The Aral Sea is technically a lake (or rather lakes); formerly it was the fourth largest lake in the world. It is much smaller now; the shrinking of the Aral sea has been caused by irresponsible water diversion irrigation schemes. To make the situation worse, the canals diverting water from the Amu-Dary and Syr Darya are not lined; consequently, there are losses due to water seeping into the desert (and creating underground aquifers), in addition to the water lost to evaporation: only 30% of the water diverted away from the Aral Sea reaches its destination, an issue denied by central Asian authorities.

This substantial alteration of a major body of water has already had numerous effects. Changes have occurred in weather patterns due to the drying up of the water body and to salt storms. Desertification has accelerated alarmingly (2 million hectares in a former aquatic area). Climate changes include hotter, drier summers and longer, colder, more snowy winters.

These changes will not just be local. Records show that the disappearance of the Aral Sea will inevitably have an effect, and possibly already has had one, on the climate of not only all of central Asia, but, according to Yablokov, southeastern Europe, India, and even China as well (Popov 1995). The growing season in the impacted regions, according to some reports, already has been shortened by two months (Yablokov, 23).

The salinity of the sea increased from 10-30 grams per liter over the 30-year period 1960–1989, and since then to 100 grams per liter. This, combined with the heavy fertilization in the attempt to restore fertility of the soils in riparian areas, leads to large quantities of residual minerals salts in the water and adjacent soils. Thus, some of the 10–12 salt storms every year are large enough to be witnessed from space by Soviet cosmonauts (Thomas 1993, p. 22), with a sharp rise in intensity and frequency of regional windstorms (Thomas 1993, p. 13). It is variously estimated that these storms carry 75 or up to 150 million tons of dust, pesticide residues and mineral salts annually, leading to desertification (Thomas 1993, p. 22), as well as sickness when it affects crops and people. The deputy head of Uzbekistan's Academy of Sciences predicted in 1989 that the changing climate could have detrimental effects on the food supply even of India (Thomas 1993, p. 23). The resulting desert, called the Ak-kum Desert, is now expected to reach 3 million hectares (about 7 million acres) in size by the year 2000 from nonexistence some three and one-half decades ago (Myrzayev 1992, p. 300).

I am particularly worried about the little discussed possible consequences of development of a land bridge to Voskreseniye Island resulting from this desiccation. When it is no longer an island in the middle of a sea, the probable residues of biological weapon activities that occurred in the past could slip through containment and may well lead to illness or deaths.

<u>Ozone depletion</u>. The FSU both suffers from, and contributes substantially to, depletion of the stratospheric ozone layers as a result of the emission of chlorofluorocar-

bons (CFCs) from, among other places, the United States as well as Russia. Reports from Russia indicate that the ozone layer itself over central Siberia was reduced by some 40% in 1995. Nonetheless, the manufacture of CFCs continues in the country with production levels of around 100 thousand tons of ozone-damaging coolants several years ago reported by Yablokov (Turkmen Press 1996). More ominously, as noted by President Yeltsin, most of the international smuggling of fluorocarbons originates in Russia.

Global climate changes. Forest changes in the FSU, particularly Siberia, contribute to global climate change forcing. Some 2 million hectares a year are felled and replaced each year officially; in reality, only 60–70% are replaced and that number is undoubtedly even less so under current economic conditions. According to one source, if the present rate of loss continues, the forests will disappear completely within the next 30 years

Most importantly, the loss of the carbon sink from such high losses of forest cover may be more significant than the loss of the Amazon forests. If we calculate that the boreal, small leafed forests of Siberia absorb some 75% of the amount absorbed by the large-leafed forests of the Amazon region, and that the latter loses some 5 million hectares per year, and the level of losses in Siberia is some 10–12 million, a simple calculation yields a loss of 7.5–9 million "equivalent" hectares, distinctly more than the 5 million of the Amazon (Yablokov, p. 19).

Biodiversity. The loss of forests not only reduces an important carbon sink, but has potentially significant negative impacts on global biodiversity. The vast relatively intact ecosystems of Russia "offer one of the last opportunities on earth to conserve landscapes large enough to allow ecological processes and wildlife populations to fluctuate naturally ." (Yablokov 1994) Efforts are being made to quantify the biodiversity of the FSU: an international project leading to a multivolume "Flora of North–East Eurasia" is under way, for example. (Radio Liberty 1994) Hopefully this will inform and support efforts to protect biodiversity, as well as activities to prevent the destruction of rare plants that might lead to important medical discoveries as well.

Nuclear issues. Among the very important issues for the United States is the question of the management of nuclear materials in the FSU. This is not just a technical, but an organizational problem. Thus, the Russian equivalent of our Nuclear Regulatory Commission, the Gosatomnadzor, is currently battling with the Ministry of Atomic Industry over whether Gosatomnadzor has the right to inspect and order corrections in the operations of the civilian and military sites operated by MinAtom. Most critical, of course, is the issue of the nuclear safety of these sites—not only from explosions, but also the potential for terrorist actions and thefts, and their potential use by individuals, organizations and/or governments against us or our allies. As with all nuclear issues, the rivalry between secrecy versus glasnost is strong: for example, the number of "secret cities" where nuclear activities took place is not yet clear. There are troubling signs, such as the arrest of the retired naval captain working for the Bellona Foundation of Norway who reported on radioactive contamination and dangers in the Northern Fleet operations. More broadly, the State Secrets Act has been rewritten to enhance secrecy: it now covers all ministries and agencies, civilian as well as military, and revokes those parts of the previous act that excluded environmental and health information from such secrecy.

Ocean dumping of nuclear waste in contravention of the London Convention is part of the pattern of careless management of nuclear waste. For many years the dumping of liquid and solid nuclear waste in the northern seas was accomplished by dumping in relatively shallow waters, far above the minimum depth agreed to by Soviet authorities in the London Convention. Temporarily suspended, at least until land-based repositories are even fuller or over-full, this pattern of dumping raises much concern in Scandinavia, and the flouting of international agreements in nuclear waste management must be of concern to everyone.

In addition, Kola Peninsula, on which major nonferrous metallurgical processing plants are located, contains more nuclear facilities, military research and civilian, than any other place in the world. This is the subject of much concern to western governments—including finally the United States. In September 1996. the U.S., Norwegian and Russian governments signed an agreement to clean up Kola's environment, especially that of the nuclear submarines that have been decommissioned. But decommissioning does not mean proper treatment of environmental hazards unless additional specific abatement procedures are implemented. Andreyev Bay, only several kilometers from the Norwegian–Russian border, has a large number of decommissioned nuclear submarines with nuclear fuel on board. Other submarines have had their reactors removed but stored in poor, ramshackle storage sites, exposed to the wind and water of the Arctic region. Some 70 are awaiting full decommissioning; only 20 of these have had their spent fuel removed. Moreover, 40 more over the next several years are expected to need similar treatment: Russian also has 80 operational nuclear submarines and two nuclear-powered cruisers stationed at bases of the Kola (Tikhomirov, p. 68). One report calls them "environmental time bombs."

The urgency felt by Norway for this major hazard in addition to all the other major hazards emanating from the former Soviet Union, is shared by the U.S. Department of Defense and the Department of State. This agreement combined with major cartographic efforts by AMAP, CIESIN, the European Environmental Agency and other alphabet organizations seeks among other goals to map the spread of radioactivity in the area, including the potential hazards to Alaska as well as Scandinavia. Hopefully, the scientific research as well as the applied dismantling of these submarines (and others in another former secret site, Shkotogo-22 in the Far East) will be performed in sufficient time to avoid small Chernobyls, as a leading Russian ecologist called these submarines.

In Russia, the problem of radioactive waste is even more severe. There are radioactive wastes facilities across the country, many of which are already full. There have been underground injections of radioactive waste in at least three places in the FSU: (1) Dmitrovgard on the Volga, (2) Krasnoyarsk on the Yenisey, and (3) Tomsk near the Ob River. A fourth site also reportedly exists. Leakage from these sites would be particularly dangerous to U.S. security and the security of other northern nations, in that the Ob and Yenisey Rivers empty into the Arctic. Can science and technology stop the transmigration of these radionuclides toward the rivers?

The international community is in fact responding to these threats. The Arctic Military and Environmental Cooperation (AMEC) pact of the United States, Norway, and Russia (September 1966), seeks to change the environmental conditions in the Russian Arctic region. Of their six projects, four concern radioactive wastes, including the joint development of prototype containers for the interim storage of spent nuclear fuel and work on technology for the treatment of liquid and solid radioactive waste. A treatment plant for low-level liquid radioactive waste is already being build in Murmansk under an earlier joint effort by Norway, Russia, and the United States. (EcoNews 1996a).

Finally, and obviously, there is the concern about potential nuclear thefts, terrorism, and associated losses. This issue is particularly difficult because we do not know how much nuclear material may be available: the quantity stored in secret cities and sites is unknown. The security systems in some of these areas are probably problematic. This is but another reminder of the dangers to other countries, not only the domestic society, inherent in an unstable society, with rampant crime and access to nuclear, as well as biological and chemical, weapons of mass destruction.

Infectious diseases. What I call "health security" is also a concern both within the FSU (stress caused by internal migration) and because of potential transmission outside the FSU. The general magnitude of the threat is enormous. The World Health Report 1996: Fighting Disease. Fostering Development, issued by the World Health Organization in 1996, makes it abundantly clear that the renewed as well as the continuing threat of infectious diseases is of the moment. To quote a lead statement in the report:. . . the re-emergence of infectious diseases is a warning that progress achieved so far towards global security in health and prosperity may be wasted unless effective development policies are formulated, and commitments are made to implement them nationally and internationally. (EcoNews, 1996a).

Some background parameters as to the depth of the global problem include the information that malaria is responsible for the death of some 2 million persons per year, acute lower respiratory infections kill almost 4 million children per year, tuberculosis 3 million, diarrhoeal diseases nearly 3 million children per year, 4 million have died of AIDS since acquiring the HIV virus that causes it, viral hepatitis B affects at least 350 million and hepatitis C some 100 million, of whom "at least one quarter of them will die of related liver disease." Further, we find that "some of the 10 million new cases of cancer [of the stomach, cervix and liver] diagnosed in 1995 were caused by viruses bacteria, and parasites" (not an unimportant matter to all of us). Migration and. . . the mass movement of populations, it is also noted in the WHO report, provide "fertile breeding grounds for infectious diseases." With 120 million persons estimated to be residing in a place different from their birth [many of these relocations are forced or unplanned], this can contribute significantly to the potential for infectious diseases already noted. Lastly, the WHO report flatly states that infectious diseases are the world's leading cause of premature death. And premature death is a major concern of the countries of the former Soviet Union—although much if not most still is from exogenous causes, especially heart and cancer, and not infectious diseases. But as we will see, the growth of infectious diseases is astonishingly high in the territories under consideration here, and therefore the threat is potentially global as well as domestic.

The potential for disease to spread as a result of travel to or from the former Soviet area, as well as travel by former residents with latent or actual disease vectors is substantial. The diseases that generate the most concern in terms of potential to spread beyond the borders of the former Soviet Union include diphtheria, tuberculosis, cholera, and polio. Diphtheria has increased to almost 40,000 new cases in Russia, and another 60,000 in the remainder of the newly independent states (NIS). While there was only a slight decrease in Russia in 1995, large increases were reported in Tadjikistan and Ukraine, among others, in the same year. There have been reports of more than 20 imported cases of diphtheria from the NIS into Europe[3] and Mongolia.[4] It is, therefore, essential that the United States and other countries maintain high levels of diphtheria immunity among both adults and children.

Tuberculosis has officially been reported as 70,000 new cases each year in Russia, but a figure of some 100,000 for this republic alone is more likely if the medical statistics system included the homeless, forced migrants, and refugees who are not captured except for special medical team surveys of persons normally not seen at medical institutions. In addition, rates among prisoners previously went unrecorded until some were recently released; virtually the entire prison population is now suspected to be ill with tuberculosis.

There is a clear and present danger of a potential explosion of AIDS, at least in the Slavic areas. Data here are very poor, and better tracking tends to show much higher rates than originally reported. For example, at the beginning of 1995, only 185 cases of HIV were reported in the Ukraine. Then, we hear that the numbers of HIV cases exploded in two Ukraine oblasts, increasing from single digit figures to over 3000 cases in early 1996. It is now reported that in all of Ukraine, some 8000 cases were recorded by October of 1996 (UPI 1996). These data are reflective not only of better reporting, but of the vast expansion of use of hard drugs transiting through the country or staying around.

Concomitantly, there is a shocking explosion in recent years of syphilis. Infection rates among juvenile females have increased dramatically; for 10–14-year-old girls, for example, the rate increased by 30 times between 1990 and 1994. Males 18 years of age appearing for the draft in the fall of 1996 present 11 times as many cases of syphilis from only three years earlier (Muhkin and Solovyev 1996). Reports indicate major increases in other venereal diseases, all of which can be taken as potential precursors of HIV and then AIDS. Continuing poor hospital conditions—over half of all hospitals in the country in recent years did not have any hot water—as well as a much larger gay population at risk than ever estimated or guessed led to the conclusion that HIV and AIDS undoubtedly will explode in and possibly out of the region.

In Russia, a continued deterioration can be expected as the State Budget recently rejected by the Duma incorporated a minimum of 40% reduction from the already low federal budgetary allocation for health issues. If this reduction is confirmed in the final annual budget adopted by the Duma, it likely will lead to continued deterioration of the health status of the population. The problems with HIV and AIDS are indicative of the state of the health system as a whole. How bad is the health situation in the FSU? Are the frightening reports just a Western bourgeois exaggeration? Perhaps a quote from an early November 1996 interview with Academician Andrey Vorobyev, a member of the Kremlin medical team who provide consultation to Yeltsin on his health, and the director of the Hematological Research Center in Moscow, should more than suffice to make the point:

For the first time in my 40-year long career as a doctor, I have found my-

> self in a position of a man who can be responsible for a patient's death. People with blood system tumors, children suffering from hemophilia, patients awaiting kidney transplants are all doomed to die. We have run out of medicines and blood transfusion systems. For over three months now our center has not received as little as a ruble for buying medicines, meals for patients and paying our electricity bills (Radyuhin 1996).

And this is from the director of a major national, even international, medical center.

If it is so bad in Moscow, what about the rest of the country? In general, it is far from bold to say it is much worse in most, but not all cases. Information on regional distributions of health (as well as environmental) patterns show major differentials, ranging in some instances by orders of magnitude. For example, the range of meningococcal infections throughout the Russian Federation in the period 1990–1991 was less than 1 per 100,000 in one territory and up to 13.0 at the maximum. Pertussis (i.e., whooping cough) ranged from less than 1.5 per 100,000 in some areas, up to 80 per 100,000 in others during the same period. Thus, possible disease proliferation depends both upon the rates in specific region contiguous to territories beyond Russian borders.

One can legitimately wonder, for example, whether recent reports about the spread of polio in the southern tier of Europe—Greece with five cases in September 1996, Yugoslavia with 20 cases reported between August 1 and October 21 of 1996, and Albania with 134 cases (14 deaths) might not reflect the newly revealed explosion of polio in Chechnya. Even partial data reflecting polio in the Chechnya area revealed 137 cases in the nine months between March and November 1995 (in addition to the approximately 150 cases in 1994). Immunization of the Albanian population seems to have reduced the new incidence to low levels during the second week of October of this year. But will it spread further? Finally, the European Union and the World Health Organization took note of the new emergence of polio and have succeeded in providing supplies and carrying out immunization in most of this region.

Secrecy has greatly hindered progress in the attempts to improve public health, in large part by hiding the dimensions of the problem not only from foreign experts, but from Russian decision makers themselves. Dr. David Zaridze of the Cancerogenesis Institute of the Russian Academy of Science speaks to this issue, having experienced it under the Soviet system.

"In the past," he writes in June 1996,

> [W]hen statistics were published on some diseases that were declassified from time to time, they were doctored to avoid incurring the wrath of bosses at all levels, from district Party secretaries all the way to Central Committee secretaries. Practically all studies on the harmful effect of environmental and occupational factors on human health were labeled 'top secret' or 'classified.' After censorship, most scientific publications contained no factual data left, and their scientific and practical value was zero.
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> For many years, I was an expert for a W[orld] H[ealth] O[rganization] working group set up to evaluate the cancer-inducing effect on human beings of various

> factors, and I know for sure that not a single scientific paper published in the Soviet Union before the mid 1980s could provide a reliable basis for concluding whether or not a given substances is liable to induce [cancer]. Soviet specialists were not worse than Western ones, they were simply given no chance to work seriously (Zaridze 1996).

Any expectation that the local and regional authorities will spend the necessary amounts for health (as well as for environmental controls) is optimistic in the extreme. In this light, one is entitled to ask whether environmental degradation and the collapse of the health system could, in fact, lead to social destabilization or even "social disintegration" as feared by UNICEF in a December 1993 publication. If this were to occur, it would have a number of obvious, and serious, security implication for the United States and its allies.

<u>Remote Sensing Initiative.</u> The issue of undue secrecy, or simply lack of information, is being addressed somewhat by agreement reached by Vice President Gore and Chernomyrdin in 1994. This agreement has laid the groundwork for remote sensing systems, which can serve a number of purposes. They include:

- Tracking nuclear material and waste
- Timely tracking of impending ecological disasters
- Determining ecological disaster areas
- Reacting to emergency situations
- Tracking geological processes, such as earthquakes
- Noting land degradation
- Tracking ice movements on rivers
- Tracking forest diseases, pest infestation, pollution impacts on tree covers
- Tacking pollution of surface and underground waters
- Assisting in cartography
- Locating mineral deposits and ensuring that their exploitation and reclamation are environmentally sound

Summary

The FSU offers an unfortunate case study of the pressures on a society that can arise when health and environmental issues are allowed to fester without being mitigated. From disease rates, to bad water, to careless management of nuclear waste—the legacy of the Soviet system is an interlinked disaster waiting to happen. Moreover, as the FSU case makes clear, the impacts of a nation ignoring its environmental health obligations are not contained only within that state's borders: they affect both its neighbors and, in this era of global transportation, far off states as well. Nuclear contamination and disease are not respectors of political boundaries, which is one of the powerful rationales for integrating environmental issues into our foreign policy and security programs.

The FSU example also illustrates several other points. For one thing, it demonstrates that the cost of doing something right the first time is usually much less than trying to clean up the problem afterwards. The trick, of course, is that in many cases the cost of cleanup, remediation, or mitigation can be passed on to someone else. In fact, the FSU government may be playing a very serious game, assuming that the Western powers will help it clean up its mess simply because they will be significantly, and adversely, affected if they don't do so. The implications of this kind of maneuvering have not been adequately considered by policymakers in the United States, or the West generally, but obviously bear on the question of when an environmental issue in a particular state becomes a matter of environmental security to another state.

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Water in southern Africa and the Middle East

Peter H. Gleick

A debate began in the late 1980s about the nature, extent, and implications of the links between environmental and resource issues and national and international security. This debate occurred at both the highest policy levels, with participation from officials like General Secretary Gorbachev and President Bush, and at the level of academic analysts, military officers, and concerned nonexperts. Among the questions asked were the role of environmental degradation or resources scarcity in affecting the stability of nations, the connections between access to resources and the aspirations and power of nations, the role of state capacity and institutional ability in dealing with environmental problems, and the role of politics and diplomacy in resolving global and regional resource disputes.

Ignoring for the time being the purely semantic aspects of these debates—about definitions of "security" or "environment" or "state capacity"—resource issues play definitive roles in the actions of states in international and intranational arenas. Nowhere is this more evident than in the area of freshwater resources. The vast majority of renewable runoff of freshwater is "international" in nature—occurring in watersheds that are shared by two or more nations. In arid and semiarid regions, in particular, these international basins are increasingly serving as a focal point of debate, negotiation, and conflict. While there is enormous potential for interstate cooperation over shared water resources, it has proven extremely difficult to reach lasting and comprehensive treaties that allocate water in regions of scarcity. Since such scarcity is likely to increase in the future as populations grow and as economic development increases demands for water, it is urgent that we better understand the connections between scarcity, international competition for water, and the various mechanisms for reducing that competition.

This paper reviews the nature of the international water problem, describes the connection with national and international security, and offer hints from several regions around the world—including the Middle East and southern Africa—about ways of reducing the risks of water-related conflict.

Conflicts over shared international rivers

Fresh water is a fundamental resource, integral to all ecological and societal activities, including the production of food and energy, transportation, waste disposal, industrial development, and human health. Yet freshwater resources are unevenly and irregularly distributed, and some regions of the world are extremely water short. As we approach the 21st century, water and water-supply systems are increasingly likely to be both the objectives of military action and instruments of war as human populations grow, as improving standards of living increase the demand for fresh water, and as global climatic changes make water supply and demand more problematic and uncertain.

Where water is scarce, competition for limited supplies can lead nations to see access to water as a matter of national security. History is replete with examples of competition and disputes over shared freshwater resources. Below, I describe ways in which water resources have historically been both the objectives of interstate conflict and the ways in which they have been used as instruments of war.

Many rivers, lakes, and groundwater aquifers are shared by two or more nations. This geographical fact has led to the geopolitical reality of disputes over shared waters, including the Nile, Jordan, and Euphrates rivers in the Middle East; the Indus, Ganges, and Brahmaputra in southern Asia; and the Colorado, Rio Grande, and Paraná in the Americas. By looking at indices for measuring the vulnerability of states to water-related conflict, tensions appear especially likely in parts of southern and central Asia, central Europe, and the Middle East, where the history of water-related conflicts already extends back 5000 years (Gleick 1994).

There is a long history of water-related disputes, from conflicts over access to adequate water supplies to intentional attacks on water systems during wars. water and water-supply systems have been the roots and instruments of war. Access to shared water supplies has been cut off for political and military reasons. Sources of water supply have been among the goals of military expansionism. And inequities in water use have been the source of regional and international frictions and tensions. These conflicts will continue—and in some places grow more intense—as growing populations demand more water for agricultural, industrial, and economic development (Gleick 1993). While various regional and international legal mechanisms exist for reducing water-related tensions, these mechanisms have never received the international support or attention necessary to resolve many conflicts over water. Indeed, there is growing evidence that existing international water law may be unable to handle the strains of ongoing and future problems. In addition to improving international law in this area, efforts by the UN, international aid agencies, and local communities to ensure access to clean drinking water and adequate sanitation can reduce the competition for limited water supplies and the economic and social impacts of widespread waterborne diseases. In regions with shared water supplies, third-party participation in resolving water disputes, either through UN agencies or regional commissions, can also effectively end conflicts.

Interstate conflicts are caused by many factors, including religious animosities, ideological disputes, arguments over borders, and economic competition. Although resource and environmental factors are playing an increasing role in such disputes, it is difficult to disentangle the many intertwined causes of conflict. Identifying potential trouble areas does little good if we have no tools for mitigating the problem. International law for resolving water-related disputes must play an important role, and I outline here recent advances in developing principles for managing internationally shared water resources. Their strengths and shortcomings are also assessed together with their ability to deal with the kinds of uncertainties that will increasingly dominate interstate disputes over water. Not all water-resources disputes will lead to violent conflict; indeed most lead to negotiations, discussions, and nonviolent resolutions. But in certain regions of the world water is a scarce resource that has become increasingly important for economic and agricultural development. In these regions, water is evolving into an issue of "high politics," and the probability of water-related conflict is increasing. Policymakers and the military should be alert to the likelihood of conflicts over water resource, and to the possible changes in both international water law and regional water treaties that could minimize the risk of such conflicts. Below I briefly discuss major issues in the Middle East and southern Africa that are urgently in need of resolution.

The international waters of southern Africa

Southern Africa is a geographically, ethnically, and hydrologically diverse region encompassing the 11 countries of Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Tanzania, Zambia, and Zimbabwe. The extent and type of water resources in these countries is very mixed, and the types of institutions set up to manage water are varied. Much of the region is semiarid and every major perennial river is shared by two or more nations. Growing populations and growing economic development in the region are putting increasing pressure on these water resources. Combined with the lack of effective joint international management of water, these growing demands are likely to lead to increased political tensions and conflict in the future, although successful international cooperation is also possible if the parties in the region make an effort to bring these issues into diplomatic discussions.

Hydrology of southern Africa

Southern Africa has an extremely variable climate and hydrologic regime. In the SADC region (Southern African Development Community), 22% of the area is considered desert or arid and receives less than 400 millimeters of rain per year, another 35% is semiarid or subhumid. Most precipitation originates from the Indian Ocean and is highly seasonal, with most areas experiencing a five- to seven-month wet season during the October–April summer (Conley 1996). The variability of interannual precipitation is also extremely high, resulting in unpredictable and often severe droughts. Droughts during the 1980s and 1990s have been particularly severe, leading to renewed interest in regional water management and planning.

The entire region is largely dependent on rainfall and river runoff for water supply, and every major perennial river in the region is shared by two or more nations. This characteristic effectively necessitates that international negotiations over the rivers be conducted and that agreements over sharing and allocation be reached. Figure 17-1 shows the main river basins in the region. Tables 17-1 and 17-2 list the international rivers of the states of the SADC region. The Congo River dominates all other rivers on the continent, with nearly 30% of the total river flow of Africa. Despite the size of the Congo, its long distance from the demand centers in the south and the high cost of moving water make it unlikely that it will play much of a role in future water supply considerations in the region. Several other rivers, however, are the focus of disputes. These are summarized below.

<u>The Okavango River.</u> The Okavango River is shared by Angola, Namibia, and Botswana and is the largest endoreic (internally draining) river in southern Africa. Most of the flow originates in Angola, flows southeast to Namibia, along the Namibian-Angolan border and then turns south into Botswana. The river drains in the world-renown ecosystem in the region—the Okavango Delta. Inflow to the delta averages

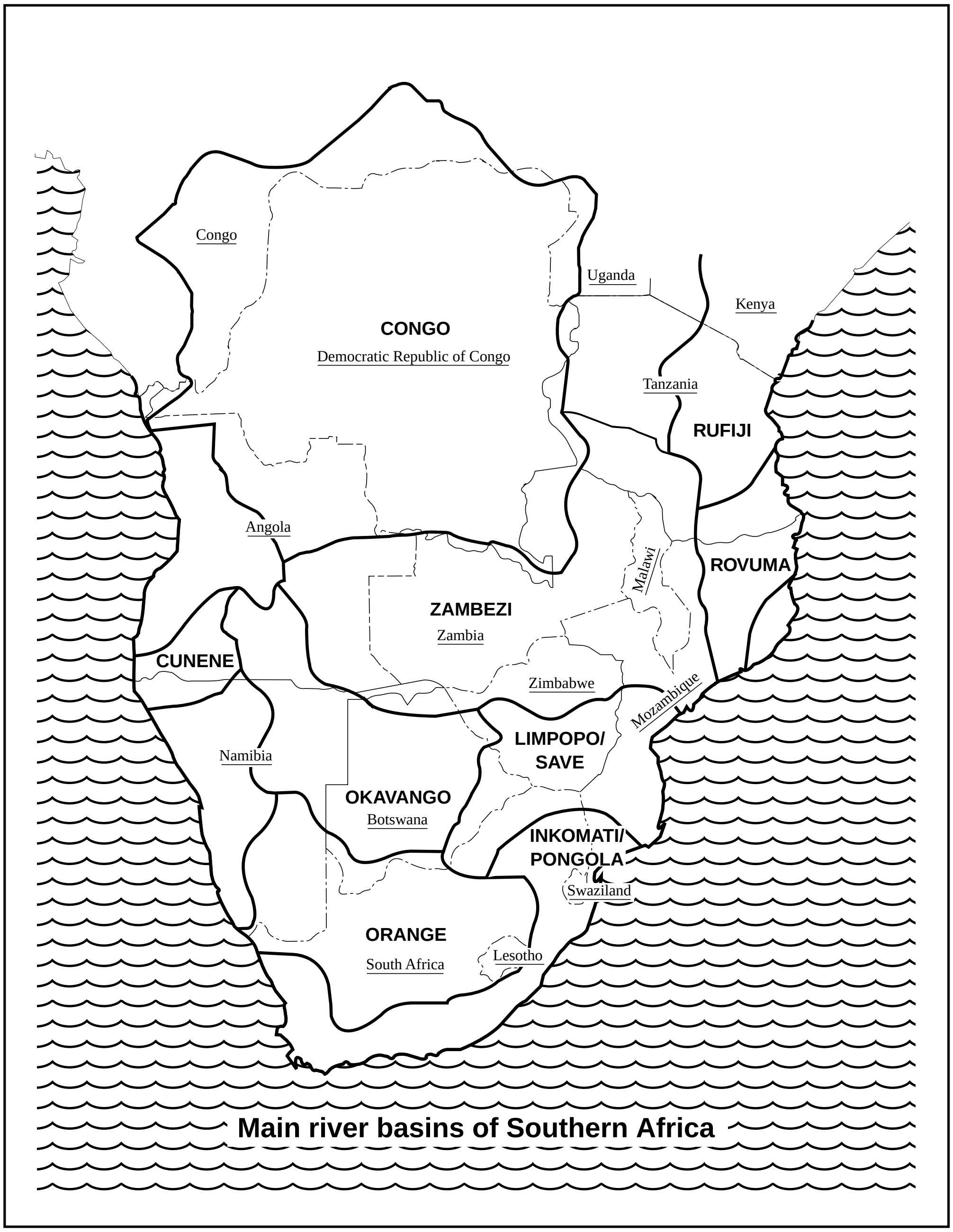

Figure 17-1. Overlap of the river basins and nations of southern Africa.

about 10,000 million cubic meters (m^3) per year. The Okavango Delta has been classified as a World Heritage Site and contains a diversity of flora and fauna unrivaled in Africa.

Several years ago, Botswana proposed a major project called the Southern Okavango Integrated water Development Project, whose main objective was to provide water for irrigators, urban users, livestock, and, in particular, a large mine. International concern about the environmental impacts of this diversion project and the quality of the environmental assessment led to an outside analysis by the International Union for the Conservation of Nature (IUCN), which was skeptical about the need for the project, concerned about its economics, and critical about its environmental implications. Fol-

Table 17-1. International rivers of the Southern African Development Community region.

Basin State	Number of International Basins	River Basins
Angola	5	Cunene, Cuvelai, Okavango, Congo, Zambezi
Botswana	5	Limpopo, Nata, Okavango, Orange, Zambezi
Lesotho	1	Orange
Malawi	2	Rovuma, Zambezi
Mozambique	9	Buzi, Incomati, Limpopo, Rovuma, Save, Maputo, Pungue, Umbeluzi, Zambezi
Namibia	5	Cunene, Cuvelai, Okavango, Orange
South Africa	4	Incomati, Limpopo, Maputo, Orange
Swaziland	3	Incomati, Maputo, Umbeluzi
Tanzania	3	Rovuma, Congo, Zambezi
Zambia	2	Congo, Zambezi
Zimbabwe	7	Buzi, Limpopo, Nata, Pungue, Save, Umbeluzi, Zambezi

Source: Ohlsson 1995.

lowing this analysis and the subsequent publicity, the project was put on hold. It is, however, reportedly of interest to Botswana (Conley 1996).

More recently, the relationship between Namibia and Botswana has been strained by Namibian plans to construct a 250-kilometer pipeline to divert water from the Okavango River to eastern Namibia and the capital of Windhoek (James 1996). Namibia, one of three riparians, intends to build an emergency pipeline to connect its Eastern National Water Carrier with the Okavango to help deal with a severe ongoing drought (as of the beginning of the 1996–97 rainy season). This development would extract about 20 million cubic meters of water from the Okavango for urban water needs. While an Okavango River Basin Commission (OKACOM) comprised of Angola, Botswana, and Namibia was formed in September 1994, there is no long-term agree-

Table 17-2. Southern African river basins and basin states.

River Basin	Basin States	Basin Area (sq. kilometers)
Buzi	Mozambique, Zimbabwe	30,000
Cunene	Angola, Namibia	110,000
Cuvelai	Angola, Namibia	125,000
Incomati	Mozambique, South Africa, Swaziland	54,000
Limpopo	Botswana, Mozambique, South Africa, Zimbabwe	385,000
Maputo	Mozambique, South Africa, Swaziland	34,000
Nata	Botswana, Zimbabwe	
Okavango	Angola, Botswana, Namibia	585,000
Orange	Botswana, Lesotho, Namibia, South Africa	950,000
Pungue	Mozambique, Zimbabwe	32,000
Rovuma	Malawi, Mozambique, Tanzania	167,000
Save	Mozambique, Zimbabwe	100,000
Umbeluzi	Mozambique, Zimbabwe	5,500
Zambezi	Angola, Botswana, Malawi, Mozambique, Namibia, Tanzania, Zambia, Zimbabwe	1,420,000
Congo	Angola, Cameroon, Central African Republic, Congo, Burundi, Rwanda, Tanzania, Democratic Republic of Congo, Zambia	3,800,000

Note: Part of Tanzania is in the Nile River basin, but the Nile is not typically considered a SADC basin. Indeed, the Congo is also rarely considered relevant to SADC water discussions, given its distance from the major demand centers in the region. There is little agreement in the literature about the actual river basin areas. These data come from several sources and are rounded off.

ment over management or allocation of the river and no agreement that this project should go forward. Negotiations and discussions between Namibia and Botswana are continuing, however, and the two countries have signed an agreement to maintain the flow of information, to share detailed feasibility studies, and to apply common principles to those studies (Communiqués, June 27, 1996 and October 15, 1996).

This issue could become the most urgent one in the region, and is already drawing attention from the international community. If the drought continues into 1997 unilateral decision by Namibia to go ahead with construction of the Eastern National Water Carrier is a distinct possibility. Such a decision would be a violation of accepted international principles governing shared international watercourses (McCaffrey 1993). These principles require joint basin management, cooperative agreements over allocations, and jointly conducted assessments to determine the environmental consequences of watershed development. Furthermore it would set a bad precedent for future water withdrawals and allocations from the Okavango by Angola and Botswana.

Conversely, if the rainy season is sufficient to mitigate the ongoing drought, enough pressure could be relieved to permit Namibia, Botswana, and Angola to work through the OKACOM to come up with a satisfactory joint basin management plan. In any case, adequate environmental impact assessments must be done to evaluate not only the impacts of construction, but the consequences of water withdrawals downstream during high and low flows, and during both routine and emergency operations. In addition, the size of the facility should be constrained by the results of the environmental assessment.

Shared rivers of Kruger National Park, South Africa and Mozambique. Six major rivers flow east from the Republic of South Africa into the Kruger National Park and then into Mozambique, where they ultimately form the Limpopo and Incomati rivers (Table 17-3). All six international tributaries are highly utilized outside of the park, and are threatened by growing populations and utilization. Kruger is the most important center for tourism in the southern African region with over 7 million visitors annually (Venter and Deacon 1995) and is one of the largest and most important centers for biodiversity in the area.

Table 17-3. Rivers of Kruger National Park and Mozambique.

River Basin	Basin Area (square km)	Natural Flow (million m^3/yr)
Luvuvhu River	3,568	395
Letaba River	13,400	553
Shingwedzi River	5,600	78
Olifants River	54,575	1,950
Sabie River	7,096	762
Crocodile River	10,526	1,238

Source: Breen et al. 1994.

None of these rivers have formal agreements that guarantee flows for Kruger and Mozambique and new concerns are now being raised about the health and quality of life of populations living in the Limpopo and Incomati watersheds in Mozambique.

The Lesotho Highlands Project. The Kingdom of Lesotho has 100% of its area over 1500 meters elevation. The highest point in Southern Africa is here, at over 3800 meters, and the country also receives the highest rainfall in the region. As a result, the country is the origin of many of the region's rivers, including the Senqu (Orange), the Mohokare (Caledon) and the Tugela. Lesotho, one of the world's poorest countries, is completely surrounded by South Africa, the continent's most affluent nation.

Almost completely devoid of exportable natural resources, Lesotho has one marketable good: water. As a result, South Africa and Lesotho entered into an agreement in the mid-1980s to construct the Lesotho Highlands Project, currently the continent's largest civil engineering works. The project consists of many phases (1A, 1B, 2, 3, and 4), but the overall goal is to divert most of the major tributaries of the Senqu (Orange) River, which flows south out of Lesotho into South Africa, north into the Gauteng Region, which is the industrial heartland of South Africa. If the project is brought to completion, nearly 50% of the country's water will be diverted to South Africa.

South Africa is paying almost all of the construction costs of the project, estimated at over $2.5 billion for Phase 1A alone (Wallis 1992). Additional support is coming from the World Bank, the European Community, and some European countries. Most of the construction contractors for the project are Italian and French. South Africa will receive all of the water and in return, Lesotho gets an annual payment for the water, consisting of a base sum plus a sum contingent on the amount of water delivered. Lesotho will also receive the power generated from the project.

As with all major dam projects, however, there are a number of costs that will be borne by Basutho people and the environment that have not been clearly evaluated. Rural development in the region, which might have resulted from more careful planning, is being poorly and incompletely handled. Recently, new attention has been focused on the project by local nongovernmental organizations, international environmental groups, and analysts at international aid agencies. Reaction from South Africa and Lesotho has been mixed and defensive, but it seems likely that some changes in the project will be made, and that some phases will be delayed or canceled. Several issues with international ramifications are described briefly below.

- Minimum environmental flows—Inadequate studies have been done on the minimum flow requirements needed to support instream ecosystems and no provision has been made to provide such requirements. An endangered minnow lives in the streams to be destroyed by the project and several endangered birds have nesting sites that would be eliminated by the reservoirs of Phase 1. Of seven known minnow populations, four will be destroyed by Phase 1. An instream flow release would reduce the economic viability of the project by decreasing both hydroelectric production and the volume of the water that would flow north into South Africa. Several people from South African water agencies, the SA Ministry of Water Affairs and Forestry, and the SA Water Research Commission expressed the opinion that Lesotho was willing to do whatever necessary, including, as one analyst put it—"kill every leopard and dry up every stream"—in order to get the financial return from selling the water to South Africa.

• Rural development—There is an agreement to provide some basic services to populations affected by the project. All villages within the watershed of the project are to receive basic drinking water supplies, consisting of standpipes within 150 meters of homes, providing a standard of 30 liters per person per day. Pit toilets are also supposed to be provided for sanitation services. Despite the fact that the first portion of Phase 1 is almost completed, this rural development has not yet begun. The development plans do not include providing electricity to all residents in the affected area despite the fact that hydroelectricity is being produced by the project and exported to other parts of Lesotho.

• Other international concerns—In addition to the international issues related to massive diversions from Lesotho to South Africa, there are concerns in the Orange River basin that the Lesotho Highlands project will deprive Orange River water users (primarily in South Africa) of sufficient water for their own needs. In addition to the Lesotho portions of the basin, the Orange includes parts of central and western South Africa and part of Namibia. Recently, these parties have begun to openly question the further development of the project and call for a re-evaluation of environmental and social impacts downstream. Ultimately, it seems likely that a renegotiation between Lesotho, Namibia, and South Africa will be necessary in order to proceed further with the project.

The Zambezi River. The Zambezi River is a sizable river with an average annual flow larger than that of the Nile. The Zambezi is shared by eight nations and is used for irrigation, hydroelectric production, wildlife refuges, mining, tourism, power plant cooling, and transportation. While it is extremely unlikely that large-scale diversions from the river toward the south will be made for decades, if ever, recent statements from South Africa have rung alarm bells throughout the region. Those statements have suggested that South Africa is thinking about, and may have at least rudimentary plans for, diverting water from the Zambezi through a canal system in Botswana or Zimbabwe to Gauteng province. Yet South Africa is not one of the eight nations comprising the Zambezi watershed. As one South African official pointed out "There are eight countries involved and we would have to talk to all of them. It would be a diplomatic nightmare (Peters 1996)."

The international waters in the Middle East

In the Middle East, ideological, religious, and geographical disputes go hand in hand with water-related tensions, and even those parts of the Middle East with relatively extensive water resources, such as the Nile, Tigris, and Euphrates river valleys, are coming under pressure. Competition over the limited water resources of the area is not new—people have been fighting over, and with, water since ancient times. The problem has become especially urgent in recent years, however, because of growing demands for water, the limited options for improving overall supply and management, and the intense political conflicts in the region. At the same time, the need to jointly manage the shared water resources of the region may provide an unprecedented opportunity to move toward an era of cooperation and peace.

In the last several years, the problem of water conflicts has merited separate explicit discussion in multilateral and bilateral Middle East peace talks. Among the issues that still need to be resolved are the allocation and control of water and the water rights of the Jordan River and the three aquifers underlying the West Bank; disputes between Syria and Jordan over the construction and operation of a number of Syrian dams on the Yarmuk River; the joint management of the Euphrates River between Turkey, Syria, and Iraq; and how to protect water quality for all riparians.

The Jordan River basin

The Jordan River is one of the most important in the region, and the locus of intense international competition. Shared by Jordan, Syria, Israel, and Lebanon, the Jordan drains an area of slightly under 20,000 square kilometers and flows 360 kilometers from its headwaters to the Dead Sea. Annual precipitation in the watershed ranges from less than 50 mm per year to over 1000 mm per year, and averages less than 200 mm per year (Naff 1992). The upper Jordan is fed by three major springs, the Hasbani (in Lebanon), the Banias (in the Golan Heights), and the Dan (in Israel). The major tributary of the Jordan, the Yarmuk River, originates in Syria and Jordan and comprises part of the border between these countries and the occupied Golan Heights before flowing into the Jordan River.

Since the establishment of Israel in 1948, this basin has been the center of intense interstate conflict, and the dispute over the waters of the Jordan River is an integral part of the ongoing conflict. When Syria tried to stop Israel in the 1950s from building its National Water Carrier, a system to provide water to southern Israel, fighting broke out across the demilitarized zone. When Syria tried to divert the headwaters of the Jordan away from Israel in the mid-1960s, Israel used force, including air strikes against the diversion facilities. These military actions contributed to the tensions that led to the 1967 Arab-Israeli war and the occupation of the West Bank and much of the headwaters of the Jordan River by Israel. Tensions also exist in the Jordan Basin between Syria and Jordan over the construction and operation of a number of Syrian dams on the Yarmuk River, and among all the riparians over water quality.

Shared groundwater aquifers

A significant fraction of Israel's water use comes from shared groundwater aquifers that underlie both the West Bank and the Gaza Strip. By some estimates, 40% of the groundwater upon which Israel is now dependent—and more than a third of its sustainable annual water yield— originates in the occupied territories (Lowi 1990 and Naff 1992). These aquifers are replenished almost entirely by rainfall on the West Bank. The largest of the aquifers, the Western (called the Yarkon-Taninim aquifer in Israel) flows west toward the Mediterranean Sea. This groundwater supply is tapped extensively by Israel, primarily from within the boundaries of pre-1967 Israel. The other aquifers are also largely controlled and used heavily by Israel, both within Israel proper and in the settlements in the occupied territories.

The control of the waters from these aquifers is one of the major sources of tension between the Palestinians and the Israelis. Among the unresolved questions are the extent to which these three aquifers are used, disputes over their control and management, uncertainties about the effects of large withdrawals on water quality, and arguments over the yields that can be provided safely.

The Tigris and Euphrates River basins

The Tigris and Euphrates rivers are among the largest in the region. Both rivers originate in the mountains of Turkey, flow south through Syria and Iraq, and drain through the Shatt Al-Arab waterway into the Persian Gulf. Several tributaries of the Tigris drain the Zagros Mountains between Iran and Iraq, and 15% of the Euphrates basin is in Saudi Arabia, though essentially none of its flow is generated there. Ninety percent of the water in the Euphrates River (average annual flow of about 33,000 million cubic meters) originates in Turkey, though Turkey only has 28% of the area of the Euphrates Basin. Almost all of the remainder of the flow originates in Syria. Turkey, Syria, and Iraq all have large and rapidly growing populations and all three countries have ambitious plans to increase their withdrawals of water for irrigation.

For 30 years, negotiations over the Euphrates among the three riparians have produced no lasting agreement, in part because Turkey, Syria, and Iraq have long been at odds with each other. For example, Syria and Iraq have opposed Turkey over its membership in a regional military alliance, while Syria and Turkey opposed Iraqi military actions in the 1970s. In the 1980s Turkey and Iraq tended to band together against Syrian military aggression, and Turkey and Syria sided with the allied forces against Iraq during the Persian Gulf war in the early 1990s.

Water-related disputes and military threats over river flows arose in the basin in the 1960s and 1970s after both Turkey and Syria began to draw up plans for large-scale irrigation withdrawals. In 1965, tri-partite talks were held in which each of the three countries put forth demands that, together, exceeded the natural yield of the river. Also in the mid-1960s, Syria and Iraq began bilateral negotiations over formal water allocations, but no formal agreement has been signed.

In the mid-1970s, Iraq alleged that the flow of water in the Euphrates had been reduced by the Syrian dam, threatened to bomb it, and massed troops along the border. In spring of 1975, the tensions between Iraq and Syria reached a peak as the two countries traded hostile statements, closed airspace, and moved troops to their borders. The angry confrontation ended just short of military action after mediation by Saudi Arabia (Gleick 1994).

In the last few years, Turkey's new water-supply projects have been the focus of new political concerns in the basin. Tensions arose in early 1990 when Turkey completed construction of the Ataturk Dam and interrupted the flow of the Euphrates for a month. Just prior to that, in October 1989, Turkish Prime Minister Ozal threatened to restrict water flow to Syria to force it to withdraw support for Kurdish rebels operating in southern Turkey. While Turkish politicians claimed that the subsequent shutoff was entirely for technical, not political reasons, both Syrian and Iraqi officials argue that

Turkey was using its power over the headwaters of the Euphrates for political goals and could do so again. The ability of Turkey to shut off the flow of the Euphrates, even temporarily, was noted by political and military strategists at the beginning of the Persian Gulf conflict. In the early days of the war, there were behind-the-scenes discussions at the United Nations about using Turkish dams on the Euphrates River to cut off water to Iraq in response to its invasion of Kuwait. While no such action was ever taken, the threat of the "water weapon" was again made clear.

Institutional issues

International law in the area of shared water resources is both well advanced and, in what may appear to be a contradiction, largely ineffective. More than 30 years of negotiations and discussions have occurred since the original statement of the 1966 Helsinki Rules governing international waters. In recent years, the International Law Commission (ILC) has refined the basic principles governing shared international watercourses (McCaffrey 1993), but these rules offer little concrete guidance to countries trying to allocate scarce water resources. Developing joint agreements is difficult because of the many intricacies of interstate politics, national practices, and other complicating political and social factors. For nations sharing river basins, factors affecting the successful negotiation and implementation of international agreements include whether a nation is upstream, downstream, or sharing a river as a border, the relative military and economic strength of the nation, and the availability of other sources of water supply.

Among the general principles set forth by the ILC are those of equitable utilization, the obligation not to cause harm to other riparian states, and the obligation to exchange hydrologic and other relevant data and information on a regular basis. Questions still remain, however, about their relative importance and means of enforcement. In particular, defining and quantifying "equitable utilization" of a shared water supply remains one of the most important and difficult problems facing many nations.

More effective than these basic principles have been individually negotiated treaties. Hundreds of different treaties signed by parties to international rivers allocate water, regulate navigation and power, monitor and control water quality, and affect all other aspects of joint management. While each of these treaties tends to be negotiated separately and individually, some have been highly effective at reducing water-related conflicts.

To make both regional treaties and broader international agreements over water more flexible, detailed mechanisms for conflict resolution and negotiations need to be developed, basic hydrologic data need to be acquired and completely shared with all parties, flexible rather than fixed water allocations are needed, and strategies for sharing shortages and apportioning responsibilities for floods need to be developed <u>before</u> shortages become an important factor.

Southern Africa's water institutions and policies

There are approximately 22 major agreements between the SADC states that affect some aspect of water development, management, and use (Ohlsson 1995). Other important aspects of the region's water policy are the new water law being prepared for South Africa and joint technical committees that, in theory, are set up to resolve disputes. Below are some of those relevant for the international problems described earlier.

<u>OKACOM 1994</u>. In 1994, Angola, Botswana, and Namibia created a Permanent Okavango River Basin Water Commission to deal with water problems on the Okavango. While this commission seems to be the ideal place to resolve any dispute over allocations and withdrawals from the river, such as those proposed by Namibia through the Eastern National Water Carrier, no such efforts have yet been made, and there seems to be some sidestepping of OKACOM in the recent dispute. Ultimately, a joint management commission will have to have authority over shared water issues if it is to be effective.

<u>Lesotho Highlands Development Authority Joint Permanent Technical Commission 1986.</u> As part of the plan to develop the water resources in the Kingdom of Lesotho, Lesotho and South Africa agreed to a joint permanent technical commission (JPTC) to address issues of rural development, environmental protection, and technical issues related to construction. The problems described earlier have not been adequately addressed by the commission.

<u>Tripartite Permanent Technical Committee 1983.</u> South Africa, Mozambique, and Swaziland created a technical committee to address issues of concern on the Limpopo, Incomati, and Maputo rivers shared by the three nations. This committee has not functioned well in the past and does not appear to be capable in its current form of addressing the environmental issues related to flows through Kruger National Park. The ending of war in Mozambique and recent improvements in relations between Mozambique and South Africa offer the possibility that water issues can now be addressed explicitly and directly. Allocations of water to Mozambique should be negotiated with the impacts to Kruger National Park considered a fundamental constraint. Recently, there has been discussion of creating a "mirror" park to Kruger on the Mozambique side of the border. water for that park should also be guaranteed.

<u>Other agreements</u>**.** Several other agreements relevant to some of the water problems described above are in place. These include a Permanent Water Commission and a Joint Irrigation Authority for the Orange River basin, created by Namibia and South Africa in 1992, a water committee for the Southern African Regional Commission for the Conservation and Utilization of the Soil (SARCCUS); and a new water sector being created for the Southern African Development Community (SADC). The problem seems to be one of a lack of institutional authority and effectiveness, rather than lack of institutions themselves.

<u>New South African water law principles</u>. South Africa is currently rewriting its entire water law, replacing the 1956 law that was enacted and enforced by the apartheid regime. While most of the principles of the new law reflect domestic concerns, Principle 11 relates directly to shared water resources, and states: "International water resources, specifically shared river systems, shall be managed in a manner that optimizes the

benefits for all parties in a spirit of mutual cooperation. Allocations agreed for downstream countries shall be respected." These principles were adopted by the South African Cabinet on November 20, 1996.

Middle East water politics and policy

Existing institutions in the Middle East are not sufficient to design and implement the kinds of conflict resolution mechanisms described above. The United Nations has played an important role, through the International Law Commission, in developing guidelines and principles for internationally shared watercourses, but it should continue to press for the adoption and application of the principles in water-tense regions such as the Jordan and Euphrates river basins. Similarly, bilateral or multilateral river treaties have been effective in the past, but they need to consistently include all affected parties, they must include a joint management committee empowered to negotiate disputes, and they should be flexible enough to adapt to long-term changes in hydrologic conditions, such as those that may result from global climatic change. Finally, disputes over shared groundwater resources are particularly important in the Middle East, yet international groundwater law and principles are poorly developed. Some recent progress has been made, but more attention needs to be given to this in the context of the Middle East.

At the broadest level, the Middle East needs a comprehensive framework for planning and managing shared water resources. If necessary, such a framework could be convened by third-party nations and institutions, and would include regional and national studies on water supply and demand, the development of standards for the collection and dissemination of data, the establishment of Jordan and Euphrates river basin authorities that include all riparians, and the identification of mechanisms for implementing joint projects. Some of the goals of a framework water convention would include identifying minimum water requirements and the equitable allocation of water, water-use efficiency capabilities and goals, means for shifting water use within and among sectors, such as through water "banks" or marketing, and objectives for providing new supplies. The opportunity for conflict over water in the Middle East is high, but peaceful, effective cooperation remains a goal worth striving for.

Summary

This paper offers a brief introduction to some of the international water issues most likely to affect international tensions and behavior worldwide, with specific reference to current issues in southern Africa and the Middle East. Because the waters of these regions are so widely shared and highly demanded, it seems likely that water-related disputes will grow in frequency and intensity in the future. Despite the wide acceptance of basic principles of behavior governing shared international watercourses, those principles are often ignored when narrow perceptions of national security are applied, when emergencies (such as droughts) occur, or when economic analyses of water projects are defined narrowly to exclude the social and environmental costs.

Because of recent political changes, southern Africa as a whole, and South Africa in particular, has the opportunity to do a number of things right. One of these is the proper management of shared international water resources. Such management will require effective joint basin management of international rivers, the integration of environmental and social factors into estimates of the benefits and costs of physical infrastructure for water supply, and the more efficient use and allocation of existing water supplies. If strong efforts are made in these areas, the cooperative management of the shared waters of the region could benefit all parties.

These same principles govern problems in the Middle East. Considerable advances have been made with the signing of the Israeli-Jordanian peace treaty, which included specific recommendations for better allocation and sharing of water in the Jordan River basin. These advances need to be extended to the other parties that share the basin.

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Energy in northeast Asia

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Regional dimensions of ecological problems are emerging rapidly in northeast Asia, where environmental degradation is closely associated with rapid economic growth. Further economic growth, however, is itself threatened by ecological limits or by mounting public concern over environmental harm. Environmental deterioration and the emergence of new resource scarcities could generate new subnational and regional conflicts in the region.

Conversely, the recognition of a shared regional and global environment—and the economic and political incentives to cooperate stemming from cross-border ecological degradation—could generate a new stimulus for regional environmental cooperation.

In approaching these issues, we draw on the central insights of three theoretical approaches, which are described below.

<u>Environmental security.</u> The term "environmental security" emerged in the 1980s in the search for an alternative to Cold War discourse. Often linked with the terms "comprehensive" and "cooperative" security, environmental cooperation was held to be a way to build confidence, while environmental degradation was portrayed as a source of interstate conflict. Environmental security was to be realized primarily within the spatial level at which environmental problems exist, that is, at the "eco-regional" level. An early round of studies aimed primarily to determine if multilateral environmental cooperation could increase trust and avoid disputes between states over resource-related issues (the "Westing school"). Some analysts concluded that environmental degradation already threatened security.

In the early 1990s, rebuttals began to appear. Security analysts argued that the concept of security entails threat capabilities and control of sovereign territory, whereas environmental issues are trans-boundary and not amenable to orthodox security solutions (that is, the exercise of military power). Others attempted to create a middle ground by confronting the multicausal, multidimensional, and nonlinear complexity that characterizes linkages between security, economic, and environmental spheres (the "Homer–Dixon school"). All these studies tend to concentrate on the potential for inter- and intrastate conflict rather than cooperation.

<u>Environmental regimes.</u> Prompted by the 1992 Earth Summit, a slew of studies on environmental cooperation emerged concurrently with the notion of "environmental security." Many drew on the institutionalist tradition of regime theory with its emphasis on rights, roles, and the centrality of consensual knowledge in substituting for the coercive power of a hegemonic state under conditions of international anarchy (the "Harvard school").

Such studies tested the hypothesis that international environmental institutions perform three functions: (1) increase governmental concern; (2) enhance the contractual environment; and (3) increase national capacity, thereby improving national environmental performance. (Here, institutions referred not only to organizations, but also to sets of rules often codified in conventions and protocols between states.)

It is also clear that states employ two different methods to cooperate on international environmental problems. The first—interstate collaboration—involves cases where vital national interests are determined to be in actual or potential conflict and typically entail a distribution of costs and commitments. In contrast, interstate coordination involves cases where all states have an interest in the benefits of cooperation. Collaboration is more difficult to achieve.

Another approach focused on the emergence of "epistemic communities" to analyze the emergence of regional and global environmental regimes. In this analysis, scientists and the dissemination of scientific knowledge to policymakers were crucial in building support for regional cooperation. Environmental interests—as articulated by scientists and their supporters—became a driving force in interstate relations, transcending strategic and economic interests.

Environmental governance. A third theoretical tradition draws from a political economy perspective to analyze the underlying economic interests and incentives of different actors in developing governance frameworks—systems of rules and enforcement strategies—to govern common-property resources. In this framework, individual users of an ungoverned common resource are subject to a "prisoner's dilemma" paradox: the maximization of individual utility undermines collective utility by depleting the resource. What is rational at the individual level adds up to a social irrationality (the Resources for the Future-International Institute for Applied Systems Analysis [RFF-IIASA] school).

The domain of regional environmental governance arguably includes cross-border ecosystems, such as atmosphere and oceans. At Nautilus, we have also developed the concept that, in the context of economic integration, domestic resources take on common property characteristics. Competitive markets for trade and investment create "prisoner's dilemma" style paradoxes for the governance of within-border resources. Economic interests in resource sustainability require cooperation to establish common regulatory frameworks not only for cross-border but for trade-exposed resources.

Early applications. In the broadest terms, the geopolitics-based realist approach suggests that environmental cooperation is strictly subordinated to "high" military and security interests. Japanese reluctance, U.S. neglect, Russian introspection, and Chinese defensiveness combine to minimize commitment and implementation. Only one small power—South Korea—has attempted to exploit the remaining space to promote multilateral environmental cooperation. But South Korea lacks the capability to kick-start a cooperative or even merely collaborative effort. Meanwhile, North Korea keeps military security issues in the forefront and participates in an irregular, half-hearted fashion. In short, geopolitics dominates geoecology.

The institutionalist school would retort that these dialogues are tentative first steps toward the construction of inclusive, cooperative regimes. Environmental threats such as acid rain will increase dramatically in intensity and impact. Environmental interdependencies will be more widely recognized as scientists provide currently lacking data and analysis to inform public opinion and policymakers. Moreover, over time, a core of institutions will create a cadre of bureaucrats and others committed to institutional expansion.

International organizations such as the United Nations Development Program (UNDP) arguably have and likely will make a difference, nurturing regional environmental networks that have continued to meet and exchange information even at the height of military confrontations in recent years. Already, normative shifts are evident in the environmental principles agreed to in the Tumen River project and other nascent regional regimes. Moreover, regional contact among domestic nongovernmental organizations is burgeoning on environmental issues, hastened by the Internet. In short, the jury is still out on whether regional regimes and institutions can overcome entrenched security-dominated and hostile political and military elites. Given the history, the progress to date is remarkable and worthy of attention.

Finally, the political economy school suggests that increased economic integration in northeast Asia provides incentives—and imperatives—for enhanced environmental cooperation. With integration, differing domestic environmental policies become nontariff barriers to trade, reducing economic growth and raising the prospects for trade conflict. Standards that are harmonized across borders, on the other hand, facilitate trade.

Moreover, resource depletion and ecosystem degradation reduce resource productivity and increase production costs, hindering economic growth. Pollution of the Tumen River, for example, is so severe that cleanup efforts must precede regional development: the need for water clean enough for industrial and agricultural use will propel cleanup and watershed management, an effort that requires cooperation among Russia, North Korea, northeast China, and Mongolia. Other cross-border, common-property resources such as the oceans and atmosphere likewise require collective action for sustainable utilization. The economic losses implied in the collapse of regional fisheries or the explosion of acid rain provide powerful incentives to cooperate in establishing common management frameworks.

Economic interdependence, ecological interdependence and the trans-boundary intergovernmental cooperation they propel will also generate a slow but irreversible shift in perceived identity. With the recognition of shared ecological resources and cross-border cooperation, a new sense will emerge of the region and perhaps of the world as a whole.

Armed with these three theoretical approaches, we have concentrated on the nexus of energy-related environmental and security problems in the northeast Asian subregion—perhaps better described as an "anti-region" given the long history of imperial domination, colonial occupation, cultural antagonism, and security confrontations that divide the region against itself.

Environmental and other security-related dilemmas

In this section, we will describe the nexus of issues between energy, environment, and security and review the current situation (in some depth) with regard to: (a) national and regional energy demand projections, (b) trans-boundary acid rain and regional oceanic environmental impacts from maritime oil transport and rapid coastal urban–industrial development, (c) regional dimensions of global climate change, and (d) financing the transition to environmentally sustainable energy development in the northeast Asian region.

Energy demand projections. The requirements for energy services to fuel development in northeast Asia has been growing rapidly in the last two decades. This has translated into a rapid increase in the rate of fossil fuel use, a trend that is expected to continue over the next two decades. Northeast Asia's shares of both global fossil fuel use and world carbon dioxide emissions are expected to continue to rise; nearly a third of the growth in annual carbon dioxide emissions through 2010 is projected to come from the region (discussed later in this chapter in Regional Dimensions of Global Climate Change). This growth in fuel use has the potential to exacerbate global problems with regional consequences, including climate change and marine pollution. Switching to alternative low-carbon and no-carbon energy sources and energy efficiency measures shows the best potential to reduce carbon dioxide emissions at low (sometimes negative) costs, and also help reduce emissions of acid gases. Options for regional cooperation to help to reduce global impacts of energy use in the region are discussed. Of particular importance are the generation of acid rain precursors that will arise from these current and projected patterns of energy use (dealt with in the next section).

Table 18-1 presents the current pattern of commercial fuel use in the countries of northeast Asia by type of fuel (British Petroleum 1996; United Nations 1994; Von Hippel and Hayes 1995). The countries of northeast Asia consumed slightly under 20% of the world's supply of commercial fuels in 1995, including about 17.5% of the petroleum products, 4.5% of the natural gas, and more than a third—almost 37%—of the world's coal. The sectoral breakdown of fuels demand in several of the countries of the region (as of 1992) is shown in Figure 18-1 (Sinton 1996; KEEI 1996; MITI 1995; Von Hippel and Hayes 1995). Here the industrial sector fraction of fuels demand is greater in the less developed countries—China and North Korea—than in Japan and South Korea. Conversely, energy demand in the transportation sector makes up a significantly smaller portion of total energy use in China and North Korea. Both North Korea and China consumed approximately 1.2 metric tons (t) of oil equivalent (toe) of end-use fuels per capita in 1990 and 1992 (respectively), while South Korea used 2.2 toe per capita, and Japan used 2.6 toe per capita (UN–ESCAP 1995)

The major point here is that energy use in Asia—particularly in China and North Korea—would seem to have substantial "room to grow" before it reaches the levels currently maintained by Japan and other developed nations. The consumption of transport services, which Chinese and North Koreans currently use very lightly, is one of the key areas that is bound to grow, with—in all probability—a significant increase in transport energy use.

Table 18-1. Fuels consumption in northeast Asia and the world.

	Energy Use in Northeast Asia and the World, 1995[a] Unit: Million tonnes of Oil Equivalent							
Country	Oil	Natural Gas	Coal	Nuclear Energy	Hydro-electric	Total	Fraction of NE Asia	Fraction of World
China	157.5	15.8	640.3	3.3	16.2	833.1	52.4%	10.2%
Chinese Taipei	35.4	3.9	17.0	9.1	0.8	66.1	4.2%	0.8%
Hong Kong[b]	4.2	-	5.5	-	-	9.7	0.6%	0.1%
Japan	267.3	55.0	85.9	74.3	7.7	490.2	30.9%	6.0%
Mongolia[b]	0.6	-	1.9	-	-	2.5	0.2%	0.0%
North Korea[c]	3.5	-	32.4		5.7	38.1	2.4%	0.5%
South Korea	94.8	9.2	27.3	17.3	0.5	149.0	9.4%	1.8%
Total Northeast Asia	563.3	83.9	810.3	104.0	30.9	1,588.8	100.0%	19.5%
NE Asia Fraction of World	17.5%	4.5%	36.7%	17.4%	14.2%	19.5%		
Total Rest of World	2,663.6	1,799.7	1,400.4	492.4	187.6	6,547.0		80.5%
Total World	3,226.9	1,883.6	2,210.7	596.4	218.5	8,135.8		100.0%

a Figures in this table are for 1995 (BP World Energy Statistics) for all countries except Hong Kong and Mongolia (1992 figures from UN) and North Korea (1990 figures from Von Hippel and Hayes, 1995).

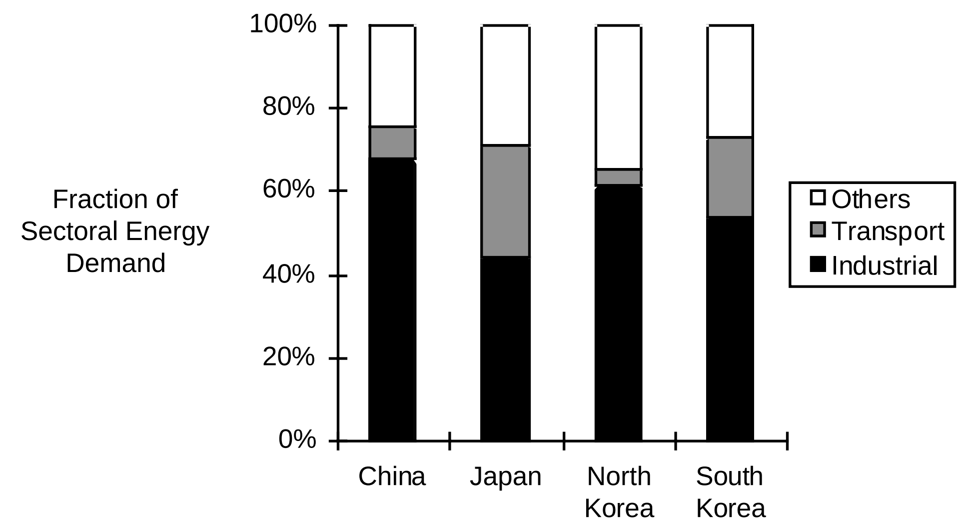
b 1995 fuels use in Hong Kong and Mongolia was probably somewhat higher than the 1992 values shown.

c Energy consumption in North Korea was probably less than the 1990 estimate in the table.

Scenarios of Future Energy Use in the Region. As projected by several research groups[1], Table 18-2 provides an overview of the results of country-level scenarios of the average annual growth rate of primary commercial energy use from the early 1990s to 2010 (scenario base years vary among research groups). In each case the "Base", "Business as Usual", or "Reference" scenario prepared by each group is reported.

Although the results of these scenarios vary somewhat, the overall pattern of strong growth in primary fuels use—in the range of 4–5% per year for all countries except Japan—is uniform. At this growth rate, energy use in the countries of the region (with the exception of Japan) will rise by about 120% of today's level by just the year 2010. As most of this fuel will continue to be fossil-derived, the increase in greenhouse gas emissions from the countries are significant enough to merit extreme global concern, in addition to the ramifications for acid rain.

Another key aspect of the projected growth in fuels use in northeast Asia is the shift in the patterns of fuel use, imports, and exports in the region. Of particular concern is the projected shift of China over the next two decades from being a small net exporter of oil in 1992 to being a very large net importer, with oil import needs second only to Japan in the region, and significantly greater overall oil demand. This shift, as empha-



Source data for graph
Units: million tonnes oil equivalent

	Industrial	Transport	Others
China	948.3	113.1	340.1
Japan	141.8	85.9	91.7
North Korea	16.8	1.0	9.4
South Korea	50.8	18.5	25.3

Figure 18-1. Commercial fuels consumption in four countries of northeast Asia (1992).

sized by Fujime (1996) and Fesharaki et al (1995) in their respective scenarios, will (together with flat production and growth in domestic consumption in the Asian countries now exporting oil—especially Indonesia) shift the focus of regional imports to the Middle East, increase competition for crude, and increase the pressure on oil transport infrastructure, including sea lanes used by tankers.

Critical energy-environmental issues for regional environmental governance

Energy-related environmental issues are not the only important trans-boundary environmental issues in the region. Other important concerns are migratory species, biodiversity, especially cross-border biodiversity management: toxic waste disposal, etc. However, energy-related environmental issues are arguably of critical importance to achieving political–military, energy, and environmental security, and are therefore central issues to be addressed in any system of regional environmental governance. The key energy-related environmental issues are:

Acid rain and alternatives to coal. Undoubtedly, the most urgent issue is the widespread and growing problem of trans-boundary, energy-related air pollution—

Table 18-2. Projections of primary[a] commercial[b] fuel use in northeast Asia: annual average growth rates from the early 1990's through 2010.

Source of Projection[c]	Country China	Ch. Taipei/ Hong Kong[d]	DPRK[e]	Japan	ROK[f]
CCICED[g]	3.88%				
East-West Center[h]	3.63%				
Institute of Energy Economics, Japan[i]	4.64%	3.96%		1.22%	4.68%
Korea Energy Economics Institute[j]					5.91%
RAINS-Asia[k]	4.54%	4.18%	5.33%	1.83%	4.98%
US DOE EIA International Energy Outlook[l]	4.49%			1.91%	
World Bank[m]	4.50%				

a Primary energy use includes fuel used in conversion and transformation processes such as coal cleaning, electricity generation, and oil refining.

b Excludes those fuels that are typically not (at present) formally traded in international markets, such as biomass for domestic cooking.

c In many, but not all cases, more than one scenario was prepared by the sources cited.

d Chinese Taipei and Hong Kong combined.

e Democratic People's Republic of Korea (North Korea)

f Republic of Korea (South Korea)

g Working Group on Energy Strategies and Technologies of The China Council for International Cooperation on Environment and Development (CCICED), Alternative Energy Strategy Scenarios for China. Prepared by the Institute for Techno-Economics and Energy Systems Analysis (ITEESA), Tsinghua University, Beijing, and China Integrated Resource Planning Promotion Network (IRPPN) International Energy Initiative (IEI). Beijing, China. April, 1996.

h Fesharaki, F., A. L. Clark, and D. Intarapravich, editors, Pacific Energy Outlook: Strategies and Policy Imperatives to 2010. East-West Center Program on Resources: Energy and Minerals. East-West Center, Honolulu, Hawaii, U.S.A. March, 1995.

i Fujime, K., "Long-Term Energy Supply/Demand Outlook for Asia APEC Nations". Energy in Japan, January, 1996. The Institute of Energy Economics, Japan (IEEJ), Bimonthly Report No. 137. 1996.

j Korea Energy Economics Institute (KEEI), [Energy Scenarios to 2030—Document in Korean]. KEEI, Seoul, Korea. November, 1994.

k RAINS-Asia Software

l U.S. Department of Energy, Energy Information Administration (US DOE EIA), International Energy Outlook, 1996. U.S. Department of Energy, Washington, D.C., U.S.A. 1996.

m The World Bank, China: Issues and Options in Greenhouse Gas Control, Summary Report. The World Bank, Industry and Energy Division, Washington, D.C., U.S.A. December, 1994. Page 39.

primarily acid rain generated by coal burning in northeast Asia.[2] Important dimensions of this issue are: (i) the sources of acid rain; (ii) the environmental, economic, and social problems associated with expanding use of coal; and (iii) the feasibility, economic and environmental costs, and security impacts of alternatives to “dirty coal,” including sulfur-reducing coal technologies, nuclear power, natural gas, solar and wind power, and energy efficiency.

Northeast Asia faces a dilemma in its choice of energy strategies. In the coming decade, rapid economic growth will drive a huge increase in energy demand. Although demand will be greatest in China, Japan and South Korea will also increase energy capacity, and North Korea and the Russian Far East hope to attract foreign investment to do the same. The dilemma is that the primary projected strategies to meet the demand—expansion of (dirty) coal, maritime oil transport, and nuclear power—are problematic, both on environmental and security grounds.

An increased reliance on coal bodes two major negative ecological impacts: a dramatic increase in acid rain-causing sulfur emissions (see Table 18-3); and a large increase in carbon dioxide and other greenhouse gas emissions. At current projections, China will emerge as the world’s leading source of carbon emissions within 25 years.

Acid rain is a problem of both domestic and cross-border proportions, with dirty coal-burning power plants in northeastern and southeastern China as the primary source. Acid rain is already at relatively high levels in much of China, the two Koreas, and Japan (and would be higher still if it were not for the buffering effect of the dust-laden winds from the interior of the continent). Levels projected by the Regional Air Pollution Information and Simulation Network–Asia (RAINS–ASIA) for 2020 will reach unprecedented levels in parts of China—much higher than was recorded at the worst sites in Eastern Europe. These estimates take into account only sulfur-related acid rain, not nitrous oxides nor ammonia, which are also increasing rapidly in the region. In short, much of the region seems to be approaching or exceeding critical levels beyond which ecosystem damage occurs, and critical loads at which severe public health damages become apparent. A particularly important impact may be the lowering of agricultural and crop productivity, especially in China, which already faces reduced food

Table 18-3. Emissions in northeast Asia by country under BAU[a] scenario (million tonnes per year).

Country	S02			NOx		
	1990	2010	2020	1990	2010	2020
Northeast China	11.9	25.3	32.5	6.9	N.A.	26.8
Japan	0.8	1.0	1.1	2.6	N.A.	4.6
South Korea	1.7	4.1	5.6	1.1	N.A.	5.1
North Korea	0.3	0.9	1.3	0.5	N.A.	2.4
Total	14.7	31.3	40.5	11.1	N.A.	38.9

[a] "business as usual" scenario

N.A. = Values not calculated by van Aardenne (1996).

Source: D. Streets, Energy and Acid Rain Projections for Northeast Asia, paper to ESENA2 Workshop, Alameda, November 1996, forthcoming ESENA working paper from Nautilus Institute.

security due to land use conversion and many other problems that afflict its ability to produce food.

The regional distribution of these acid rain precursors is an important political issue laden with conflict potential. According to recent and comprehensive estimates (refer to Table 18-4), some 37% of Japan's acid rain problem is sourced from China. In North Korea, 34% is sourced from China and another 30% from South Korea. The region's oceans are especially vulnerable: 15% of China's sulfur emissions are deposited in the ocean, while for South Korea and Japan the figures are 51% and 48% respectively. On both land and sea, acid rain undermines biological productivity with implications for major crop and fish food sources, and threatens to degrade the region's forests.

Worries over widespread, regional environmental damage have prompted some policy analysts, including in Japan and Korea, to promote nuclear power as an alternative to coal-fired power. However, there are also large environmental externalities associated with nuclear power, including the risk of Chernobyl-style accidents, the production of radioactive waste, equipment and buildings, and routine radioactive emissions.

Currently, nuclear power accounts for between 25–50% of electricity generating capacity in Japan, Taiwan, and South Korea. This fraction is projected to increase to 35–55% by 2010. Japan is committed to breeder reactors as is South Korea's nuclear establishment, along with mixed-oxide fuel plutonium recycling (although South Korea has forsworn plutonium reprocessing).

The construction of nuclear power plants continues to pose risks, due to siting and seismicity problems (in Japan), shoddy and corrupt construction (South Korea), lack of operating and maintenance funds (Russian Far East), and lack of safety, regulatory, and trained operating staff (North Korea). Emergency evacuation poses intractable, likely impossible problems in all the densely populated states of the region. None of the states has adopted a nuclear waste disposal strategy. Public accountability for nuclear power decisions is low or nonexistent in the region. Proliferation issues are a concern in some cases (North Korea).

Another option is to switch to natural gas, either imported by sea, or, more hypothetically, by massive pipeline construction from Siberia through China to North and South Korea, and on to Japan. These two strategies both entail very large capital investments in the supply and transport side, as well as in retrofitting cities to distribute natural gas. As a relatively clean fuel, however, natural gas has some strong advantages over coal, oil, and nuclear power, assuming losses of methane in transmission systems can be reduced.

The large environmental and security externalities associated with dirty coal and nuclear power make both unattractive. There is a third alternative, however, based on a combination of clean coal, fuel switching, and energy efficiency. The "Third Path" strategy is focused on minimizing waste, on both the demand and supply sides of the energy equation. It requires investment in widespread improvement in the efficiency of end-use in all sectors, as well as expansion of coal-based electricity supply which controls sulfur emissions.

Studies at Lawrence Berkeley Laboratory, for example, have shown that China's energy services have grown more (since the early 1980s) from its increased end-use efficiency than from investment in new energy supplies. Substantial and relatively

Table 18-4. Transboundry Transport of Acid Rain in Northeast Asia. Regional source-receptor relationships for Eastern Asia. Shown in the percentage of each receptor's deposition from the responsible source region. Columns represent sources and rows receptor regions. The last column presents the total deposition on each region

Shown is the percentage of each receptor's deposition from the responsible source region. Columns represent sources and rows receptor regions. The last column presents the total deposition on each region in kilo-tonnes S/yr and the last row presents each country's emissions in kilo-tonnes SO_2/yr.

	China												Japan							South Korea				
Receptor / Source	NE Plain	Shenyang	Hebei-Henan-Anhue	Beijing	Tianjin	Shandong	Shanxi	Taiyuan	Inner Mongolia	Jiangsu	Shanghai	Zhejiang	Chugoku-Shikoku	Chubu	Hokkaido-Tohoku	Kanto	Kinki	Kyushu-Okinawa	North Korea	North	Seoul-Inchon	South	Pusan	Total Deposition
Oceans	14	1	11	1	1	8	1		2	14	8	6	2	2	2	1	2	2	3	3	4	4	8	1257
China																								
NE Plain	74	4	8	1	1	2	1		5	1									3					620
Shenyang	66	17	7	1	1	3	1		2	1									1		1			13
Hebei-Henan-Anhui	1		61	5	4	5	6	3	3	11	1	1												707
Beijing			41	32	7	4	7	2	5	1														17
Tianjin	1		38	24	26	5	3	1	2	1														31
Shandong	2		18	1	1	35	2	1	1	40	1													359
Shanxi			29			2	48	15	4	2														119
Taiyuan			15			2	44	35	2	1														10
Inner Mongolia	28	1	14	2	1	1	9	1	45															209
Jiangsu			19			4				62	8	6												346
Shanghai			3			1				24	53	18												37
Zhejiang			7			2				19	11	61												111
Japan																								
Chugoku-Shikoku	10	1	6	1	1	2	1		1	3	1		35	13	6	1	1		3	3	4	2	4	36
Chubu	1		1							1				73	13	3	1				1	1	1	29
Hokkaido-Tohoku	3		3			1				2				14	39	20	5	1	1	1	2	2	4	57
Kanto	2		3			1	1			2	1	1		2	6	50	19	1	1	1	2	2	4	21
Kinki	2		3			2	1			3	1	1		2	2	7	42	13	1	1	2	4	11	49
Kyushu-Okinawa	4		7	1	1	5	1		1	8	2	2		3		1	4	29		1	2	5	21	23
North Korea	17	1	6	1	1	3	1		1	3									29	6	30		1	170
South Korea																								
North	3		4			2				4	1								3	30	37	8	5	67

Source: G. R. Carmichael and R. Arndt, Deposition of Acidying Species in Northwest Asia, paper to ESENA2 Workshop, Alameda, November 1996, forthcoming ESENA working paper from Nautilus Institute.

cheap, fast, and incremental (therefore, low risk) efficiency options also exist for North Korea. Similar potential exists in South Korea and to a lesser extent in the most advanced and technologically innovative economy in this region, Japan.

The "political economy" of the "Third Path" revolves around the prospective cost to Japan of unrestrained growth in coal use in China (and to a lesser extent, in the two Koreas) on the one hand; and the cost to China of reducing its sulfur emissions on the other. Technological controls include: (1) desulfurization of fuel oil, coal, and diesel fuel before combustion; (2) desulfurization of fuels during combustion by additive processes and flautist bed combustion; and (3) capture of sulfur after combustion by flue gas treatments such as wet limestone scrubbers.

Relatedly, these and end-use efficiency measures overlap with those required to reduce China's prospective energy-related greenhouse emissions to acceptable levels. Thus, the Organization for Economic Cooperation and Development (OECD) countries as a whole, and Japan and South Korea in particular, have a strong common interest in financing the requisite technological advances in China's energy sector.

Energy-related marine degradation. Energy-related marine degradation in the Sea of Japan and the Yellow Sea are a second critical issue for regional environmental security. Such degradation stems primarily from the transport, storage, and runoff of oil, and the ocean dumping of ship ballast and nuclear waste. Both oil and nuclear pollution have already ignited interstate hostilities.

The potential impact of increased fossil fuel consumption in northeast Asia on the marine environment are manifold. Increased use of fuels in northeast Asia and Asia generally is likely to affect the global marine environment. As noted above, oil imports by China alone are projected to reach 132 million metric tons(t) of oil equivalent (toe) per year by 2010, and net imports to the Asian APEC region as a whole are expected to rise from about 75 million toe in 1992 to 432 million toe in 2010, an increase of nearly 500%. What this means is that much more oil will be on the high seas, traveling to Asian countries from exporting nations that are increasingly in the Middle East. Fesharaki et al (1995) estimate that 95% of crude oil imports to Asia and the Pacific will come from the Middle East by 2010, as compared with 70% in 1993. This vast potential increase in tanker traffic brings with it significant possibilities for increased marine oil pollution from both routine and accidental spills.

The most visible and prevalent example of direct spillage of energy products into oceans is that of "oil spills." Crude oil and refined products spill during routine operation of offshore oil rigs, from oil tanker filling and off-loading operations, during the cleaning of tankers, as spillage from other (non-tanker) ships that use petroleum fuels, and as a result of leakage from undersea pipelines, as well as during less frequent but better-publicized oil tanker accidents and "blowouts"[3] at offshore oil platforms. Table 18-5 provides estimates of the current sources and magnitude of marine oil pollution. Of the sources listed, marine transportation, including oil tanker traffic, is estimated to be the largest single source.

Oil spills are toxic to many forms of marine life, as well as fouling beaches and affecting other ecosystems and man-made installations along the shoreline. Oil floating on the ocean's surface can coat marine birds, making them unable to fly, reducing the insulating properties of their feathers (so that they can no longer stay warm), and usu-

Table 18-5. Sources of petroleum hydrocarbons in the marine environment (millions of tonnes annually).[12]

Source	Probable Range	Best Estimate
Natural	0.025 - 2.5	0.25
Atmospheric Pollution	0.05 - 0.5	0.3
Marine Transportation	1.00 - 2.60	1.45
Offshore Petroleum Production	0.04 - 0.06	0.05
Municipal and Industrial Wastes and Runoff	0.585 - 3.21	1.18
Total	1.7 - 8.8	3.2

From Lazarus, M., and D. Von Hippel, A Guide to Environmental Analysis for Energy Planners. Stockholm Environment Institute-Boston (SEI-B) Report, SEI-B, Boston, MA, USA. 1995.

Original Source: M.H. Katsouros, Chapter 5 in Hollander, J.M., Editor, The Energy-Environment Connection. Island Press. Washington. D.C., USA. 1992.

ally eventually killing them. Oil spills disrupt the food chain by killing phytoplankton and zooplankton[4] at or near the oceans surface. This is important throughout the world, but nowhere more than in Asia, with its high population densities and where so many people (A) live in coastal areas, and (B) depend on marine products for food and livelihood. Food chain disruptions that reduce yields (or usable yields) of fish and shellfish put an additional burden on a regional food production system that is already operating with little capacity to spare.

Heavier oil products, and the heavier fraction of crude oils, sink to the bottom, where they can coat shellfish beds, making shellfish and other invertebrates inedible. Damage from oil spills may persist for many years, as compounds contained in oils can remain both in the bodies of organisms and in marine sediments. Oil spills can be spread rapidly by tides, currents, and winds, making them a long-term threat to the regional and global marine environment, in addition to their acute local impacts.

The risk of oil spills in the Asian region in general, and in northeast Asia in particular is likely to increase as more and more tankers carrying oil from the Middle East and elsewhere to China and other nations add to congestion in the relatively few major sea lanes in the region (Valencia 1995).[5] These sea lanes are already crowded by tanker and freighter traffic serving the booming economies of the area.

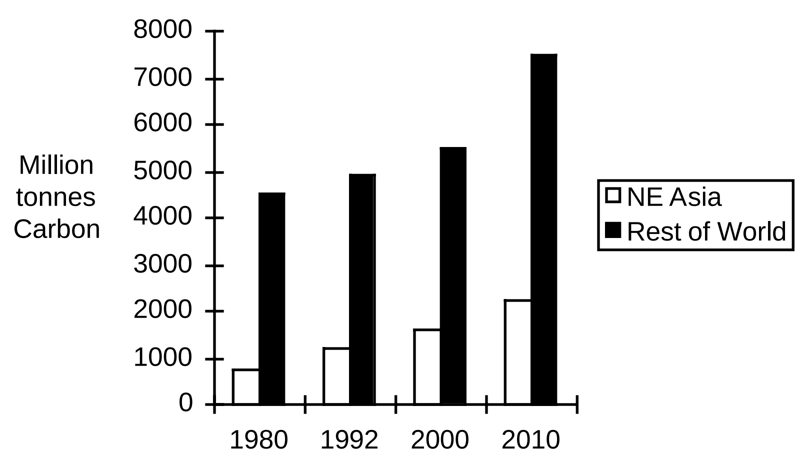
The Northwest Pacific Action Plan already has identified imperatives for regional cooperation to manage sea lanes and traffic, respond to catastrophic oil spills, monitor marine oil pollution and nuclear waste dumping, and promote cross-border integrated coastal management strategies to reduce runoff.

The role to be played by navies in monitoring and verifying such agreements, enforcing agreements concerning the use of sea lanes and hazardous straits, and responding to catastrophic spills, is an important subject for further investigation. Such cooperation might spill over into high geopolitics by providing opportunities for inclusive confidence building between otherwise adversarial states.

Regional dimensions of global climate change

The current and projected growth in energy use in northeast Asia, particularly in a "business-as-usual" world, means that the region will play an extremely important role in either exacerbating or reducing the impacts of global climate change. Scientific consensus is that increasing concentrations of greenhouse gases in the atmosphere, prominently including carbon dioxide and methane emitted by fossil fuels combustion, will cause global climate to change in the next several decades, if such changes have not already occurred (IPCC 1996). The impacts of climate change will vary widely across the globe, but those countries with the largest, least affluent populations per unit land area will likely be among the most vulnerable. China and North Korea, therefore, face somewhat of a dilemma. Development is necessary in both human and political terms, but one of the impacts of development is likely to be increased greenhouse gas emissions, which puts those countries (and the globe) at risk from the impacts of climate change.

Projected greenhouse gas emissions. Figure 18-2 shows a comparison of one set of greenhouse gas emissions projections for northeast Asia as compared with projections for the rest of the world. In 1980, the countries of northeast Asia accounted for just under 15% of the world's total carbon emissions. By 1992, the fraction had grown to



Source data for figure
Units: million tonnes carbon

	NE Asia	Rest of World
1980	761	4,491
1992	1,197	4,896
2000	1,604	5,465
2010	2,246	7,502

Figure 18-2. Historical and projected carbon emissions in northeast Asia and the rest of the world.

nearly 20%. By 2010, based on projections by Fujime, carbon dioxide emissions from the region will be 23% of the global total, reaching a level nearly double that of 1992. This means that the region will have contributed nearly one-third of the total growth in global carbon emissions between 1980 and 2010. (Fujime 1996) Table 18-6 provides estimates of historical and future greenhouse gas emissions by country for northeast Asia.

Although the process of climate stabilization is one that will of necessity take the better part of a century if not more, an increase like that shown in Figure 18-2 in only the next two decades will make stabilization that much harder to achieve. Managing the growth in fossil fuel use in northeast Asia is therefore one of the keys in reaching greenhouse gas stabilization targets as soon as possible.

<u>Regional impacts of global environmental problems.</u> In addition to some of the environmental impacts of marine pollution related to petroleum transport that are noted in the previous section, northeast Asia is vulnerable to a range of environmental impacts of global climate change. These environmental impacts, in turn, could (and, in many cases, would) spawn a broad range of social and economic impacts in the region.

The environmental impacts of global climate change in the northeast Asia region include, but are not by any means limited to:

Table 18-6. Summary of recent and future CO_2 emissions from fuels use in northeast Asia (carbon dioxide emissions in million tonnes carbon).

Year	China	CT/HK[a]	DPRK[b,c]	Japan	ROK[d]	Total NE Asia	Total Rest of World	Total World
1980	403	27	22	272	37	761	4,491	5,252
1992	697	51	36	326	87	1,197	4,896	6,093
2000	1,011	79	52	334	128	1,604	5,465	7,069
2010	1,515	94	114	339	184	2,246	7,502	9,748
Growth, 1980 - 2010	1,112	67	92	67	147	1,485	3,011	4,496

[a] CT = Chinese Taipei and HK = Hong Kong figures combined.

[b] DPRK = Democratic People's Republic of Korea (North Korea)

[c] 1992 value for DPRK is value calculated for 1990 in Von Hippel, D., and P. Hayes, The Prospects for Energy Efficiency Improvements in the Democratic People's Republic of Korea: Evaluating and Exploring the Options. Nautilus Institute Report, Nautilus Institute for Security and Sustainable Development, Berkeley, CA, USA. 1995. The 1980 value for DPRK emissions was taken to be 60 percent of the 1990 value (based roughly on the difference in coal consumption between the early 1980's and 1990 as reported by the UN). Projections for DPRK carbon emissions were based on increasing the 1990/92 value at 4.5 percent per year, which is somewhat less than the growth rate in energy use implied by the RAINS-Asia base case scenario, but accounts for the fact that the DPRK would probably shift toward less carbon-intensive fuels (if indeed its energy use could grow as projected).

[d] ROK = Republic of Korea (South Korea)

Additional source: Fujime, K., "Long-Term Energy Supply/Demand Outlook for Asia APEC Nations". Energy in Japan, January 1996. The Institute of Energy Economics, Japan (IEEJ), Bimonthly Report No. 137. 1996.

- Changes in average temperature
- Rising sea levels and related impacts
- Changes in precipitation and in the frequency and severity of storms
- Changes in the distribution of ecosystems

A complete discussion of all of the different potential impacts of global climate change in northeast Asia is beyond the scope of this paper. The work of the Intergovernmental Panel on Climate Change (IPCC) and others is available for those interested in obtaining more detailed information (Fujime 1996; IPCC 1996b; Von Hippel 1995).[6]

Change in global temperature. Based on a range of different scenarios of human fossil fuel use and other activities that emit greenhouse gases, the IPCC estimates that global mean temperature will increase by between 1.5°C and 4.5°C, with a "best estimate" of 2.5°C, by 2100, relative to pre-industrial (late 19th century) temperatures. These temperature changes will not be evenly distributed. Temperature changes in northern latitudes, including the Russian Far East, Mongolia, the Koreas, Japan, and northern China, are projected to be higher than changes in the tropics; temperature changes at inland locations are expected to be greater than near the ocean; and the warming of the climate will be greatest in the late autumn and the winter. The recent inclusion of the effects of atmospheric aerosols (small particles, for example, of soot or of sulfate compounds) into the modeling of future climate has changed the projected picture somewhat, particularly in northeast Asia. Aerosol emissions in northeast Asia, particularly in China, have the effect (in computer simulations for the period to 2040–2049) of reducing the temperature increases caused by higher $C0_2$ concentrations. Though aerosols would appear to exert a cooling effect, the magnitude of their impact on climate is still quite uncertain (Kattenberg et al 1996).

Sea level rise. One of the most-noted potential impacts of climate change is sea level rise (SLR). The increase in global temperatures affects the level of the oceans in two different ways. First, when surface ocean waters are heated, they expand and occupy more volume of ocean basin, thus causing sea levels to rise. A second mechanism that causes ocean waters to rise occurs when elevated temperatures cause the ice in polar and mountain glaciers and ice sheets (principally the Antarctic and Greenland ice caps) to melt, and the meltwater from these bodies of ice eventually or directly adds to the amount of water in the ocean. Due to temporal lags in the ocean/ice cap/atmosphere system (Haq 1994), it has been estimated that this second mechanism will provide a relatively minor contribution to overall sea level rise, particularly in the early years of the next century. The behavior of some of the world's major ice sheets—and their response times to climate changes—is quite uncertain.[7] The IPCC's mid-range projections of future sea level rise are for an increase of 20 centimeters by 2050 and 49 cm by 2100 (Warrick et al 1996). Here again, the range of uncertainty is substantial.

The most obvious regional (as well as global) impact of sea level rise (SLR) brought on by climate change is inundation of coastal lands by the higher water level of the oceans. Hundreds of meters to many kilometers of shoreline inundation may result from tens of centimeters of SLR. In China, much of the most productive land is located in the coastal plains, often with an altitude on the order of a few meters above sea level. One estimate suggests that a one-meter rise in sea level would, in the plains of the

Lower Liao and Pearl Rivers, and the north and east China coasts, inundate 92,000 square kilometers, affecting 65 cities and a population of 67 million people (World Bank 1994). Coastal wetlands are especially at risk from increases in the sea level associated with climate change. Studies of several areas in the Asia and Pacific region estimated wetland losses of 35 to over 90% (Nicholls 1994). The changes in climatic variability discussed below—changes in the severity, frequency, and location of storms, for example—will compound the impact of sea level rise, and place coastal ecosystems, infrastructure, and populations even more at risk.

Change in the amount and timing of precipitation, and of the frequency and severity of storms. In a future where the climate has changed, some areas of the Asia and Pacific region may receive more rain than at present, and some less. Note that the various climate models do not necessarily agree on the pattern that these changes will take. For a doubling of atmospheric CO_2 concentrations, model predictions for the East Asian Seas region show slight increases in precipitation (zero to 20%) in both summer and winter (Kattenberg et al 1996), but there is likely to be a large variation of changes in different areas. Estimates for China show an increase in both summer (9.3%) and winter (12.7%) precipitation, but with attending small decreases in both cloud cover and soil moisture (World Bank 1994).

Along with changes in the amount of precipitation, and perhaps more importantly, changes in the timing of precipitation are expected. These changes include the shifting of storm patterns and changes in the severity of storms. Changes in the severity of storms and floods—and erosion exacerbated by storms and floods—as well as in the timing and amount of water discharged by rivers could (as pointed out by the impact of the recent floods in North Korea) have a devastating effect on both ecosystems and on the dense human populations of coastal and river areas. For island areas of the region (particularly in the south), this effect may include an increase in the frequency of hurricanes and typhoons to areas that already experience them, and a widening or shift in the belts of such storms to adversely affect additional island and mainland areas. Rising seas will exacerbate the damage caused by these weather phenomena.

Changes in the distribution of ecosystems. The climate-related changes discussed above can change plant growth conditions, and thus the distribution of ecosystems, in several ways, including:

• Changes in plant growth rates. These changes may include increases in plant growth promoted by higher concentrations of CO_2 in the air. In addition, the northerly portions and countries of the region (such as Japan), may experience greater plant growth as higher average temperatures bring growing seasons. In some areas. decreases in growth rates may result from intolerance of high temperatures by the indigenous plant species or from changes in the amount or timing of precipitation (Topping, Qureshi, and Sherer 1990).

• Changes in forests due to changes in temperature, precipitation, and evaporation. Northeast Asia (particularly the Russian Far East) is home to large tracts of forests, and these forests are important both ecologically and economically. Forest ecosystems are sensitive to climate changes, but due to the long lives and long maturation periods required for large trees in forests, they will probably be less able than other ecosystems to adapt to changes in climate (Qureshi 1993a).

• Changes in the distribution and prevalence of plant and animal pests and diseases, and the changes in the susceptibility of plants and animals to these maladies due to their exposure to changes in temperature and precipitation, and other climate change-induced stress.

• Changes in ocean temperatures and their effects on ocean productivity .

• Changes in biodiversity and species distribution. All of the changes noted above have the potential to alter the distribution and range of plant and animal species, including both domesticated crops and livestock and native flora and fauna. Although the natural inclination of managed and natural ecosystems under climate stresses is to migrate to more favorable areas, these migrations could be frustrated by an inability to migrate—due to physical isolation or limitations posed by other natural or by human communities—or by a rate of climate change that exceeds the ability of those ecosystems to migrate (Qureshi 1993b).

Potential interaction of regional and global environmental problems. Some of the existing (and probable) local and regional environmental problems now experienced in the northeast Asia region may be increased in magnitude—made more difficult to cope with—by the impacts of global climate change. Some of the interactions between global climate change and local/regional impacts could include:

• Climate change-induced stress on ecosystems (through changes in temperature, precipitation, storm patterns, or sea levels) may pose an additional challenge to ecosystems affected by acid precipitation, such as forests and lake communities. Ecosystems stressed by local air pollutants (particulate matter, sulfur oxides, or lead, for example), erosion, or deforestation are also more vulnerable to climate change, as are the human populations that depend on them.[8]

• Sea level rise brought on by climate change will add to salinization (salt intrusion into fresh surface waters and groundwater) in areas—such as around several coastal cities in China—where groundwater pumping and other human activities have caused the land to subside. In areas where subsidence is already a problem, climate change will increase the rate at which land is inundated.

• River, lake, and estuary ecosystems stressed by additions of silt, municipal wastes, and industrial effluents will be more vulnerable to the impacts of climate change. These ecosystems—including fish and other products important for humans—will also be less able to adapt to a changing climate than if they were healthy.

Interaction of climate change and marine pollution impacts with existing human problems in the region. There is a list of potential social and economic impacts of climate change much too long to describe in any detail here.[9] Some of the impacts that are most likely to exacerbate existing human problems in northeast Asia are described briefly below.

• Pressure on agricultural resources and accelerated desertification caused by climate change may accelerate cross-border migration, particularly from China into Russia (a process already under way).

• Climate change impacts may further undermine the ability of North Korea to feed its population, possibly resulting in increased military pressure on South Korea, or rendering the process of reunification more economically burdensome.

- Higher temperatures would likely lead to increased use of air conditioning, which would, in turn, lead to higher fuel consumption for electricity generation, and higher emissions of local and regional air pollutants (as well as greenhouse gases).
- Salinization of estuaries that are the breeding grounds for fish and shellfish caught in shared regional waters (including the East Korea Sea/Sea of Japan) will affect yields of ocean products for all countries, possibly exacerbating conflicts over maritime resources.
- Additional oil pollution of the oceans of the region (as a result of greatly expanded oil imports by the region) could strain relations between countries sharing shipping lanes and marine resources.
- Climate change impacts may increase the human and economic costs of natural disasters (such as catastrophic storms) in the region, and spread even thinner the emergency resources available for responding to such disasters.

Innovative energy financing and the trade-environment interface. Meeting the capital requirements of environmentally sound and secure energy expansion in northeast Asia is the foundation for a strategy aimed at realizing energy and environmental security.[10] The role of private trade, capital, and investment flows will be critical in facilitating the transfer of environmentally sound, affordable energy technologies to China and the two Koreas. Indeed, regional energy development will have major impacts on the global availability of capital for this sector. Meeting the increased demand for fuels in northeast Asia will require huge capital investments in a number of different sectors. including:

- Electricity generation, particularly to meet high growth in demand in China
- Coal mine expansion, and especially, coal transport facilities in China
- Oil exploration and production facilities, including offshore platforms
- Oil tanker docking facilities, again especially in China
- Oil refining—including both new refineries and equipment to allow existing refineries to use high-sulfur (sour) crude oil from the Middle East
- Natural gas pipelines—virtually all of the proposals for bringing gas to northeast Asia involve costs of $10–20 billion or more, even before accounting for the costs of local distribution networks (Valencia and Dorian 1996)
- Liquefied natural gas (LNG) terminals (at up to $1 billion each) and transport vessels (at on the order of $250 million each)

These potential investments will compete among themselves for scarce foreign and domestic capital. They may also compete for capital with environmental investments such as pollution-control equipment, coal mine safety investments, and energy efficiency investments. The potential constraints on the capital markets that can supply the region have not been quantitatively examined in a thorough fashion as yet, but availability of capital remains a consideration that will determine, in part, the evolution of energy infrastructure in the region.

Electricity generation in Asian states that are members of the Asia-Pacific Economic Cooperation (APEC) program is projected to increase from its 1991 level of 235 GWe to 1,100 GWe in 2010—an annual 8% increase. This projected increase will require some $297 billion over the 1991–2000 period; and an additional $557 billion from 2000–2010. About 62% is projected to be in China. It is highly improbable that China can sustain this rate of capital investment in electric power plants, which amounts to an average of $26 billion/year. Moreover, the investment required to control China's sulfur emissions with best available technology would amount to $34 billion per year, according to the RAINS–ASIA model. (However, to the extent that the model used myopic governmental estimates for energy demand projections in the model, it may have overstated the amount of acid rain precursor emissions that have to be controlled: also, the model used primarily international control costs, not the lower costs that would ensue in a scenario wherein China commits to control on a large scale, including domestic manufacture of the control equipment—which would drive cost down by approximately another 25%.)

The critical missing link in this political economic equation is how much it would cost to achieve "best available technology" sulfur reduction in China using energy efficiency rather than emission control technology. If acid rain in China can be reduced by energy efficiency, cleaner coal and control technologies, and a combination of fuel switching (natural gas supplemented by renewables), a substantial fraction of the annual costs referred to above could be avoided. The potential gains may persuade China to accept substantial "green" and efficiency investment by Japan and other donor states. On the other hand, the threat of China's acid rain may induce Japan and South Korea to lead in innovative financing of China's energy sector in ways that provide more energy in China at lesser cost.

At this stage, however, no one has compiled the basic elements of the overall regional picture that would allow a strong argument to be put forward to this end. Similarly, until these elements are assembled, no one can evaluate properly the claim of nuclear power to be the only technological and economic solution to acid rain in the region. What is evident already is that China's constrained governmental budget dictates that the costs and effectiveness levels of control technologies be reduced and adapted to Chinese conditions. At the regional level, common regional energy and energy-related pollution principles and ceiling standards could also help lift the tide for everyone toward a sustainable energy future.

Japanese energy security: de-emphasizing nuclear power?

In this section, we will compare and contrast Japanese and American paradigms of energy security and examine the technological and security implications of the different concepts of energy security that underlie policy, especially with regard to nuclear power and plutonium energy strategies. We will also survey the situation on the Korean Peninsula and the activities of the Korean Peninsula Energy Development Organization as an example of new, cooperative approaches to achieving nuclear nonproliferation via multilateral diplomacy in northeast Asia.

Concepts of energy security in northeast Asia

The long-standing elite consensus in Japan that nuclear power—and, in particular, plutonium—is a critical element in a secure and sustainable energy supply for its economy is now unraveling. The breeder reactor accident in early 1996, the recent local antinuclear referendum vote and the loud regional debate concerning Japan's plutonium and latent nuclear weapons proliferation potential have led to an unraveling of this consensus. The Japanese political culture requires that the consensus be reconstituted before a new public face is put on its nuclear program, and before the plutonium and/or strategies based on light water reactors (LWR) can be abandoned or de-emphasized. This process will take some years.

In the past, specialists from the United States have played a crucial "sounding" board role in facilitating the changes in Japanese energy and security policy at times of change. Ironically, Japan's energy paradigm, including the nuclear power policy, originated in the United States in the 1950s-1970s period. At the same time, Japan represents an economic and technological model for other Asian countries such as South Korea and served as a transmission belt for this worldview to these other states.

Underlying the commitment to Japan's nuclear program is an energy paradigm built around the notion of energy security. This latter notion has deep roots in Japan's 20th-century experience. Historians argue about whether Japan attacked Pearl Harbor because of the U.S.-led oil supply cutoff to Japan in 1939, but most Japanese accept this link to their disastrous involvement in World War II. The OPEC 1973 and 1979 crises also had profound impacts on Japanese concerns about loss of supply of fossil fuel imports. Recent concerns about global warming have provided further impetus to an environmental argument in favor of nuclear power, to reduce greenhouse gas emissions.

Today, however, the concept of energy security is vague and hazy in Japan. The concept is used in Japan to justify investment in stockpiling, and in nonfossil fuel cycles such as nuclear power. In particular, the plutonium-fueled breeder reactor offered a vision, via a uranium-fueled LWR bridge, to a self-reliant energy supply for Japan's economy.

Bureaucratic factors have also come into play. Japan's nuclear energy establishment has been able to pursue what would appear to be an overly ambitious, costly energy security strategy in part because the well-known vertical fragmentation of Japan's public administration has promoted inertia and inhibited the evolution of a comprehensive energy security policy. Japan's energy planning framework is heavily dominated by the bureaucracy, and is vertically fragmented with poor coordination. In spite of the work done by other government, academic, business, and nongovernmental sectors on alternative energy strategies, Japan's energy policy does not give due regard to full economic, environmental, and security costs of various energy mixes.

Operational concepts of energy security

It must be admitted that there are few models of what to look for in an economically and environmentally sound operational concept of "energy security" of the kind that should underlie U.S. and Japanese policy. Three literatures are relevant here. First, and most widespread, is the qualitative focus on political factors affecting energy supply.[11] The second is contractor literature for studies of oil versus nuclear power impacts on import vulnerability, which are still relevant to Japan. The third, the most powerful analytically, is the methodology developed at the World Bank to analyze the economics of investing in "insurance" against fuel supply cutoff in mountainous, landlocked, and isolated, small island states.[12]

All three need to be combined—the first analyzing the long-run stability of oil supply markets and interdependence between suppliers and consumers; the second approach that focuses on the relative supplier market diversity of fuel types; and the third economic methodology that looks at the risk-benefit dimensions of various "insurance" strategies to create an operational concept for energy security in any state, but especially in Japan. It would be very revealing to conduct an analysis comparing the Republic of Korea (ROK), Republic of China (ROC), and Japanese strategies on this score, using the same method. Four important working hypotheses arise from this broad approach to energy security:

<u>Hypothesis 1</u>: A close analytical look at "energy security" will demonstrate that nuclear power increases rather than reduces overall energy import dependence and vulnerability to cutoff; and that over the relevant time horizons, the risk (defined strictly as the probability of fossil fuel cutoff *times* the cost of such cutoffs) is smaller than the assured costs of investing in stockpiling oil, coal, uranium etc., technological (nuclear power/breeder) diversification; and that the fastest, safest, cheapest way to reduce the risk still further is to (a) reduce demand for imports by investing in energy efficiency at home; (b) export energy intensive industries to fossil fuel suppliers, thereby creating interdependence and economic disincentives to cutoff Japan's fossil fuel imports; and (c) invest in home-grown renewables and geothermal energy in Japan—something that the Japanese are already pursuing at home and in their bilateral aid (especially with China), but with a low priority.

<u>Hypothesis 2</u>: In Asia, as in Europe (reflected in the Energy Charter), subregional integration will create economic incentives to build a subregional energy infrastructure in northeast Asia, which will in itself increase energy supply security. This approach would emphasize "regional energy security."

<u>Hypothesis 3</u>: Investing in energy security via this alternative path will generate the technological innovation in Japan itself that will make it cheap—and therefore feasible—to create an environmentally sustainable energy development path for China; and that without this element, acid rain from China will reach unacceptable levels in Japan within 20–30 years. Thus, the concept of energy security must now incorporate environmental externalities—a new twist.

<u>Hypothesis 4</u>: Deregulation of the Japanese power industry is hastening a shift away from the plutonium future. Taken together with the Monju, Tokai, and siting problems afflicting the nuclear power industry, deregulation thus predisposes Japanese energy decision makers to be open-minded to new paradigms for the concept of "energy security." This process will force utilities to make decisions more on the basis of expected returns rather than according to administrative guidance and/or in response to government subsidies. It will also likely expand the circle of decision makers over time (initially to financial and insurance business circles in addition to utility executives, and later to stockholders and the general public as informed by the media). Thus, the time is propitious for such an exercise.

It is timely to reexamine the existing paradigm because: (a) other OECD countries have given up or cut back on nuclear power and plutonium; (b) international reaction to Japan's plutonium program remains severe: (c) alternate sources and strategies for energy are decreasing rapidly in cost; (d) the energy sector is undergoing deregulation, which in itself calls for a fundamental reconsideration of energy strategy; and (e), the general atmosphere of public mistrust and scandal, the Monju incident, and the recent referendum against siting nuclear power plants.

In short, the time is opportune for a thorough reconsideration of Japan's energy security strategy. In that reformulation, nuclear power should be considered on an equal footing with other sources of energy, in economic, environmental, and security terms.

Criteria for U.S. policy initiatives for environmental security in northeast Asia

The United States and Japan have crucial, unique, and complementary intellectual, institutional, technological, and economic resources to apply to regional energy cooperation. These capabilities arise out of their respective security, economic, and technological positions. Together, these two great powers can jump-start the process of environmental cooperation within the northeast Asian region, whereas left to their own devices, Japan may hesitate, and the United States may neglect these crucial regional issues. This process is an important component of a regional comprehensive security strategy. It will build confidence between the states in the region in ways that will assist in resolving major geopolitical security dilemmas via cooperative engagement.

In this section, we will present a set of criteria for selecting from candidates for a U.S. and Japanese joint policy initiative to respond to the energy dilemmas in northeast Asia, and we will present a set of concrete policy options for consideration by decision makers in search of "environmental security" in this region. In particular. we will analyze the interrelationship between nuclear nonproliferation objectives in this region, and the geopolitical confidence-building potential of energy-environmental cooperation in northeast Asia.

Policy criteria: In general, we suggest that a successful candidate for a U.S. policy initiative on the issues analyzed in this paper will meet *all* of the following criteria:

1. The initiative should generate constituency and political will in the United States, Japan, China, and North and South Korea, including the creation of a common image of the environment and security issues. This may require the development of an epistemic view (for example, by a collaborative remote sensing network) to help characterize problems and resolve scientific uncertainties.

2. The initiative should draw on complementary strengths (analytic, capacity building, technology) of the United States, Japan, and other states in the region, and match these capabilities very carefully with needs.

3. The initiative should build, not destroy, confidence. It should cultivate the perception of common identity and should support:
   - Mutual interest (e.g. migratory birds between Japan and North Korea)

- Self interest (which does not always build mutual interest or confidence)
- Contribution of all parties (no handouts)
- Overlapping security and environmental concerns (geopolitical importance)
- Environmental interdependence (all nations share the atmosphere)
- Shared identity (long-term impact—potential to cause xenophobia)

4. The initiative should use existing institutional channels to implement initiatives. These might include:
   - UNDP/Economic and Social Commission for Asia and the Pacific (ESCAP)-NEAREP (issues—donors not funding it; technology ministries versus foreign ministries; United States and Canada are not members)
   - Asian Institute of Technology–Program for Asia Cooperation on Energy and Environment
   - APEC working groups (issues—multilevel process; diffuse; no concrete agenda)
   - Asian Development Bank(ADB) (issues—Democratic People's Republic of Korea (DPRK) is not a member; biggest funder of NEAREP; chief economist is interested)
   - United Nations Environment Program (UNEP)–Northwest Pacific Action Plan (NOWPAP) (resources to do something on cooperative ocean management; integrated coastal zone management already signed off on; agenda is momentous in scope; DPRK attended every meeting, but the process is now stalled)
   - Korean Peninsula Energy Development Organization (KEDO) (only multilateral institutional framework for engaging DPRK; although it is now partly confidence-destroying due the DPRK's continuing threat to go nuclear [extortion destroys trust]; parties are learning about each other but not trusting each other as a result of KEDO's negotiations, but it has an open-ended agenda and can, should the United States, South Korea, and Japan so decide, include issues beyond nuclear energy and heavy fuel oil)
   - Parallel nongovernmental track with DPRK (U.S. and Japanese foundations went to the DPRK to negotiate areas for cooperation including agriculture/biotechnology, medical technology, energy and environment, cultural
   - Concerted bilateralism by United States and Japan (carve out an area at margins in countries where Japan and United States have relations)
   - Tumen River Area Development Project (TRADP) (UN spawned activity; big vision, no reality; have MOU on environmental principles—already signed; progressive)
   - Northeast Asia Economic Forum (run by East-West Center; will take up energy-environmental issues in 1997
   - Northeast Asia Cooperation Dialogue (NEACD)/Susan Shirk at IGCC (Track II funded by DOE; senior officials discuss political/security issues; DPRK mostly not involved

5. The costs of the initiative, especially at the beginning, should be both small and shared.

Overall, expected outcomes should focus on building confidence and the habit of dialogue in the region; creating institutional and intermediate-level management capacity to deal with problems we are defining; and generating specific and tangible environmental benefits over a definable-time horizon.

With these criteria in mind. we suggest the following candidates for a joint U.S.–Japanese initiative to promote environmental security in the northeast Asian region (these are not exclusive):

- An Acid Rain Monitoring Network, which could include the existing Japanese monitoring network, RAINS–Asia passive monitoring system, and remote sensing or popular monitoring (schools, public etc.) system
- Local government capacity building initiatives, which could include staff development in areas of, for example, air pollution, energy efficiency, green buildings, public health, and environmental regulations
- Nongovernmental organization (NGO)–public education campaign, focusing perhaps on acid rain
- Initiatives to make long range energy planning transparent, an important confidence-building measure that would be the basis for any effective collaboration
- An Energy Efficiency And Clean Coal Fund, including technology demonstrations
- An Air Pollution Regulatory Policy and Implementation Network
- A Nuclear Fuel Cycle Cooperation project, which would comprehensively cover aspects of nuclear material management, including spent fuel, waste storage, disposal and security systems

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3. A blowout occurs when the well-head where the flow of oil from a well is controlled fails catastrophically, allowing oil, driven by high gas and/or liquid pressures in the well, to flow out of the well and into the surrounding environment.

4. Phytoplankton is a name used to denote the class of microscopic-to-barely-visible aquatic plants that are the base of much of the ocean's food chain. Phytoplankton include marine algae, diatoms, and other photosynthetic organisms. Zooplankton are the micrometer-to-millimeter-size animals that, like the phytoplankton they feed on, float along near the surface of the ocean. Zooplankton include the larval and juvenile (young) stages of a number of commercially and biologically important organisms, such as crustaceans (e.g. shrimp and crab) and mollusks (shellfish). Zooplankton in turn serve as food for small fish and other animals.

5. Most of the tanker traffic headed for the region will need to pass through the straits that lie between Malaysia/Singapore and Indonesia. Traffic headed for Southern and Eastern China, the Koreas, and Japan usually passes through the Formosa or Luzon Straits, the East China Sea, and often the Korea Strait to service tanker terminals on the east coasts of South Korea and Japan.

6. For example: Chapters 6 through 10 in Intergovernmental Panel on Climate Change (IPCC),*Climate Change 1995: The Science of Climate Change*;*Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change*;*, Scientific-Technical Analyses, Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change*; Chapters 1 through 12 in *Climate Change 1995: Impacts, Adaptations, and Mitigation of Climate Change: Scientific-Technical Analyses*;*Contribution of Working Group II to the Second Assessment Report of the Intergovernmental Panel on Climate Change*; and Chapters 6 to 10 in *Climate Change 1995: Economic and Social Dimensions of Climate Change., Contribution of Working Group III to the Second Assessment Report of the Intergovernmental Panel on Climate Change. A*ll three volumes were published for the IPCC by Cambridge University Press, New York, in 1996.

7. For example, elevated temperatures could cause the West Antarctic ice sheets to slide into the sea at an increasing rate, which would produce a quicker contribution to sea level than if the sheets simply melted *in situ*. There may be a significant lag in the melting or movement of ice sheets as a result of elevated global temperatures. In other words, sea level rise could continue long after temperature changes have stopped.

8. A particular example here is the recent flooding in North Korea. In this case, the lack of forest cover (due to a combination of the impacts of war and inadequate soil conservation) undoubtedly played a role in exacerbating the impacts of severe storms. Though the storms of 1995 and 1996 may not (or may) have been altered by climate change, their devastating impacts serve as a warning for what could happen in the region when the effects of a changing climate impinge upon areas already under ecological stress.

9. For more information on this topic, the reader is encouraged to see *Climate Change 1995: Economic and Social Dimensions of Climate Change. Contribution of Working Group III to the Second Assessment Report of the Intergovernmental Panel on Climate Change*. New York: Cambridge University Press. 1996.

10. See: Resource Dynamics Corporation. *Financing Worldwide Electric Power: Can Capital Markets Do the Job?* U.S. DOE report, contract DE-ACOI-92FE62489; H. Razavi 1996. *Financing Energy Projects in Emerging Economies*. Tulsa: Pennwell Books; APEC Energy Working Group. *Action Program for Energy* (http://www.dpie.gov.au/resources.energy/energy/apec/action1.html) INTERNET.

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12. See, for example, the Joint UNDP/World Bank Energy Sector Assessment Programme, *Issues and Options in the Energy Sector,* reports for Burundi (No. 3778-BU, June 1982) and for Fiji (No. 4462-FIJ, June 1983).

Part five: Specific threats

CO_2 and transportation

Lee Schipper

The insidious problem

One of the most vital parts of our economy and our lives is transportation. No one doubts that transportation returns enormous benefits to our economies, both private benefits to each of us using the system for personal (or goods) mobility and collective benefits as well. But transportation is not without important side effects, or externalities that impose costs not only on system users but on others and on the natural environment as well. The carbon dioxide (CO_2) generated thereby is not the worse thing we face, but it is unfortunately linked with the potential for some serious long-term environment problems. What makes this particularly insidious is that we really don't have a mechanism for dealing with it socially. We don't have a social consensus. We don't have a political consensus. And after we have dealt with many of the other problems in connection with transport and energy use, we'll find we may still have CO_2 to deal with.

The inventory of transportation concerns includes: accidents, noise, dirt (particulates, residues, and junk), congestion, space use (pavement and suburban sprawl), habitat disruption, emissions (pollution and CO_2), and energy use (oil), the deadly sins of transportation. Some of these problems are getting better. Fewer people are killed per kilometer of travel every year in most Western countries. Air pollution, at least in the United States, tends to be getting better. Noise and material recycle are improving.

The other problems are worsening. Most of these have local impact, which means both that they do not threaten the global system and that local controls can and eventually will be applied by those directly concerned.

Oil depletion and CO_2 are different. This is the plight of the global commons; local motivation is absent and the entire system can prove to be uncontrollable and ultimately self destructive. It is not currently a big problem; it is not now a costly problem. But if you look at it from a long-term, societal point of view, it may indeed be very serious, even a threat to human survival.

"Transport for a Sustainable Environment," a recent National Academy of Sciences study in which I was a member, focused on CO_2 and habitat disruption as factors that threaten future generations the most, i.e., threaten sustainability. The CO_2 generated by transportation may not be the worst problem we face, but it is unfortunately linked with the potential for some serious long-term environment problems. What makes this particularly insidious is that we really don't have a mechanism for dealing with it socially. We don't have a social consensus. We don't have a political consensus. And after we have dealt with many of the other problems in connection with transport and energy use, we'll find we may still have CO_2 to deal with.

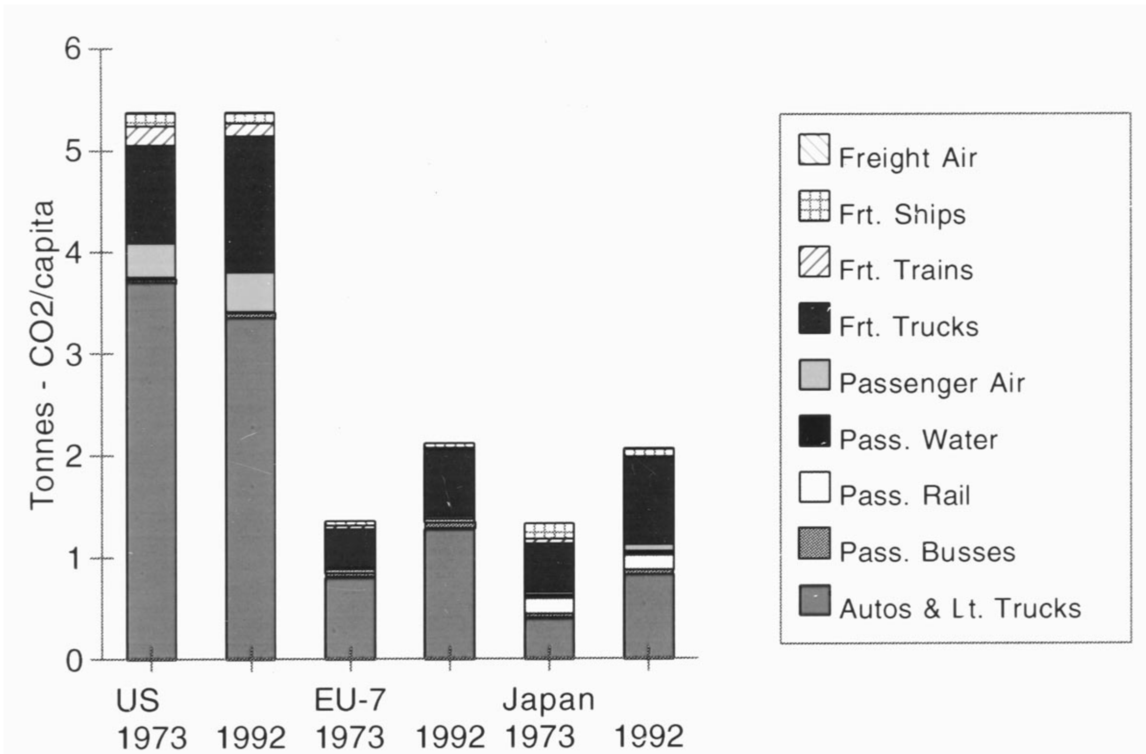

Figure 19-1. CO_2 emissions from transportation by the advanced countries of the world for 1973 and 1992.

CO_2 from transportation

CO_2 emissions from travel are shown in Figure 19-1, which portrays the specific sources: cars, buses, railroad, or air travel. It is interesting that, on a per capita basis, the U.S. emissions were level over the period shown; in fact they even fell a bit, while they rose in the seven European countries depicted and Japan. The reason that emissions rose in those countries is increased mobility: people are moving around more. Whereas, in the United States, while we are much more mobile than we were 20 years ago, we went through a period in which we basically shrunk the size of our cars. Fuel use per kilometer in the United States is now rising again after falling for more than 20 years.

Worldwide mobility is increasing due to several factors— growth in the number of cars, the spread of suburbs, the addition of more women to the workforce, and an expansion in the amount of leisure time. Fuel prices have stayed relatively low, particularly in the United States. We haven't had any real long-term constraints in either transport or oil. We have cheap energy, particularly in the United States. Relative to the high price era of the early 1980s, even Europe is basically better off than it was ten years ago.

People want mobility, particularly if it is cheap

People want their mobility and it is very difficult for politicians, whether in Los Angeles or Washington or Paris, to step in the way. Voters, however, are not interested

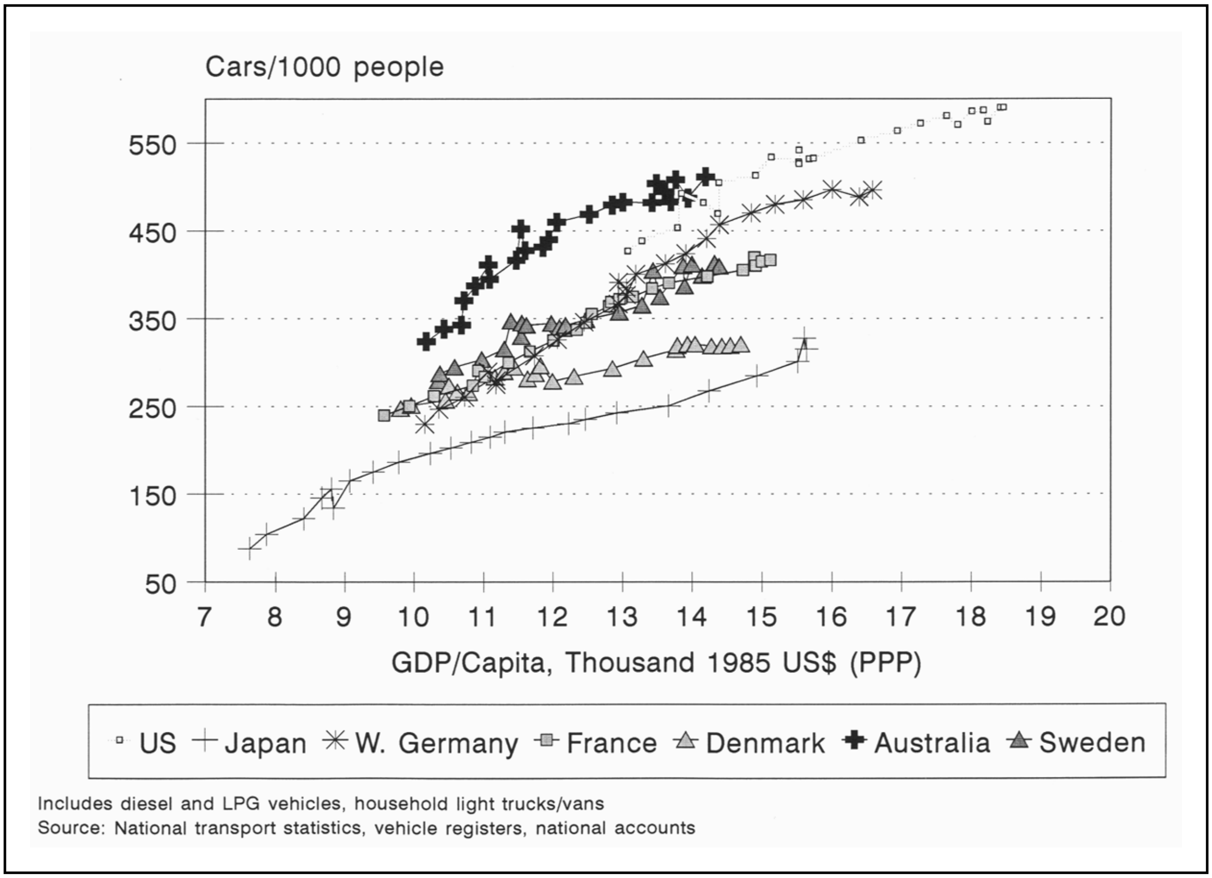

Figure 19-2. Automobile ownership versus Gross Domestic Product (GDP).

yet in paying for decreased CO_2 emissions. Certainly for a while, the United States and Canada broke the trend, with higher prices and the comprehensive automotive fleet emission (cafe) standards. But the trend-break is over. Where once we had a period of climbing fuel efficiency, we now see emissions increasing per unit of travel as people purchase larger cars. Unless we understand the people problem—how people, and for that matter how goods, move around—we can't deal with CO_2, and that is why we are paralyzed today.

The coupling between our income and our mobility is strong (Figures 19-2 and 19-3). Basically, as we get richer, we move around more. In the long run it has been getting cheaper to move around. And as a result it is very difficult to say, don't move. In the Third World and Eastern Europe the number of cars went as the inverse square of the Gross Domestic Product (GDP). Even during the years when the economies were collapsing, the number of cars was rising steadily.

But it is not just people that move around. As wealth increases freight transportation increases (see Figure 19-4) and becomes a greater source of transportation problems (noise, road damage, accidents, air pollution) and also a greater source of CO_2. While the United States has relatively efficient trucks and trucks represent only about 35% of the freight hauled, trucks are gaining their fuel-use share of freight hauled. This is because there is a trend toward smaller shipments, because trucks are faster in many markets, and because diesel fuel itself is cheap. Everybody wants things quickly and

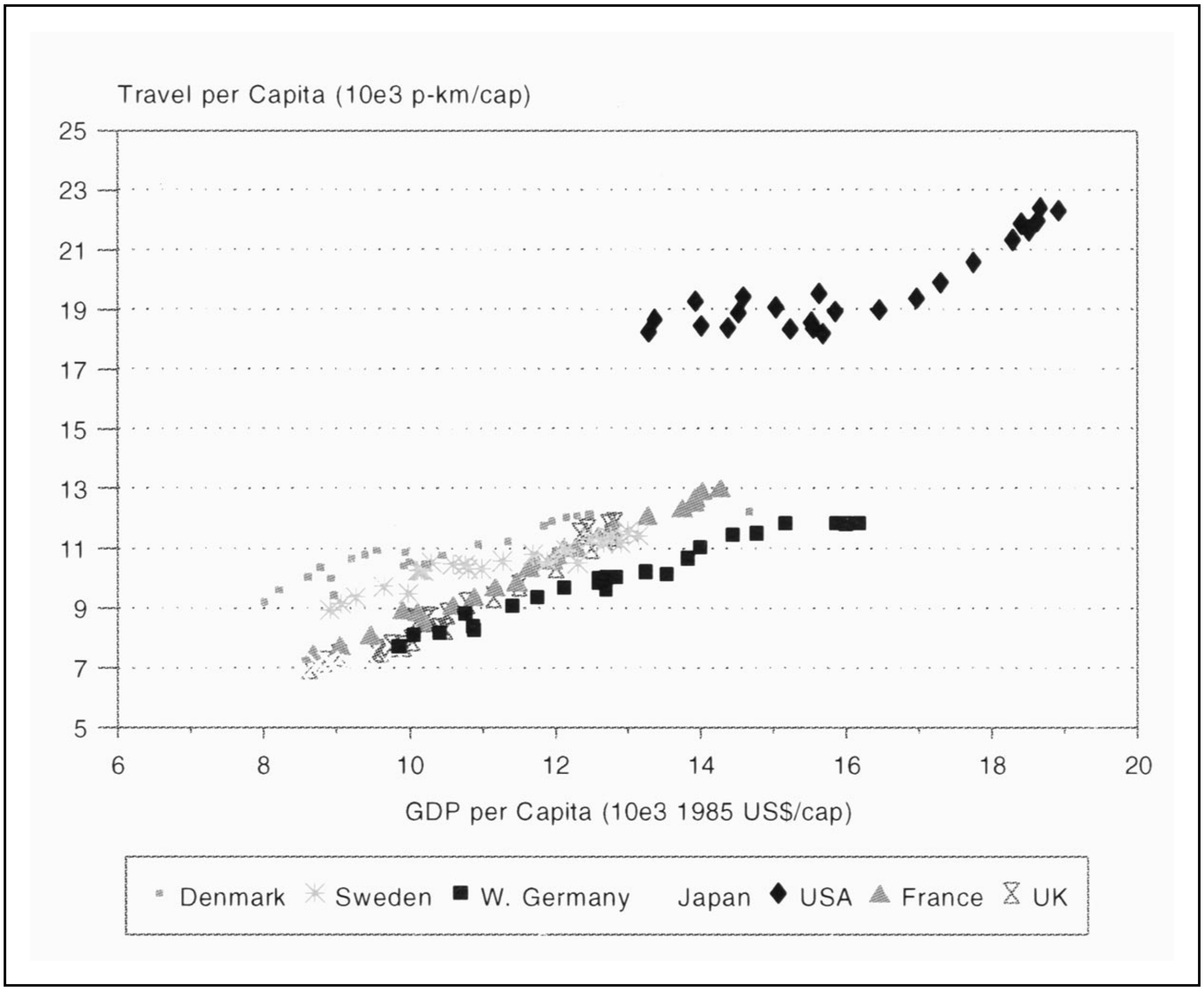

Figure 19-3. Domestic travel versus Gross Domestic Product (GDP).

just in time so load sizes are decreasing and distances are increasing. The laptop that I use in California came to me by overnight express. The computer company in New York sent it by air and by truck at no cost to me, since the transportation cost was small compared with the price of the computer. Two-thirds of that shipment was the packaging for the computer. You can begin to understand why we are using more energy and releasing more carbon per unit of freight.

Technology?

Technology promises solutions, but the question is whether technology is enough. Technology feeds back on people. What we do more efficiently, we enjoy more and actually do more, eating up some of the efficiency savings. This is illustrated in Figure 19-5, which shows fuel inefficiency as gallons per mile or liters per 100 kilometers. What you see is that the United States, which was much more inefficient than countries in Europe, showed an enormous improvement. This came to an end in 1991 as our efficiency improvements flattened and began to reverse. At the same time the changes in Europe have really been very small, because while we were shrinking our

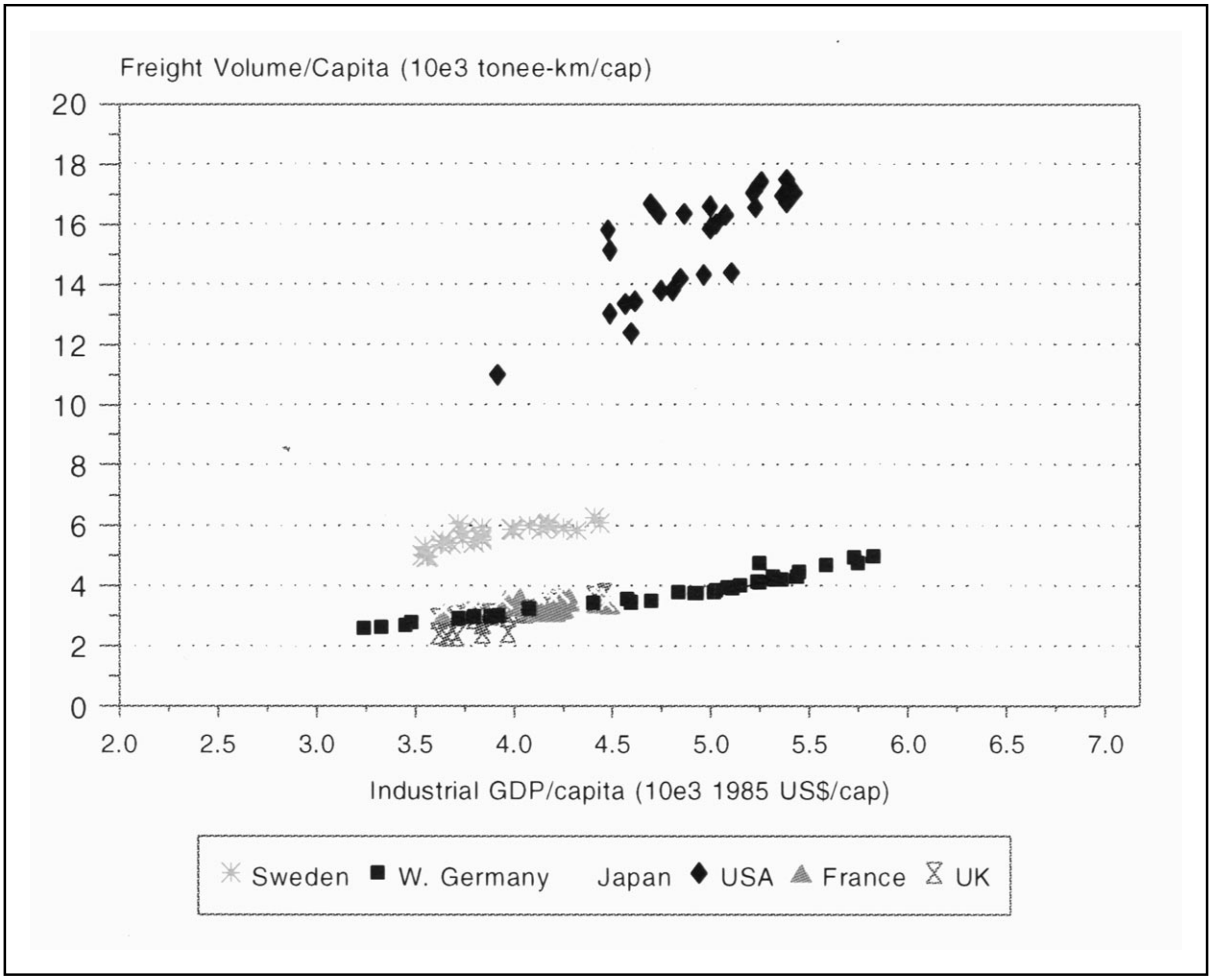

Figure 19-4. Freight volumes versus industrial Gross Domestic Product (GDP).

cars, the Europeans were getting bigger cars.

If you look very carefully, you find that it takes far less energy to move a kilogram of car a kilometer than it did 20 years ago (Figure 19-6). We are much more efficient. But what is happening is that we are using our technology to give us bigger cars (Figure 19-7) and more performance, with little saving in energy use, and energy in this case is almost the same as CO_2. In France, for example, half of the new cars sold are diesel. Never mind the air pollution problems the diesels give, diesel fuel is priced so low that you get about the same cost per mile of driving as we do in the United States. It is not surprising that the French are so enthusiastic over diesel cars and are driving them 50% more than those who have gasoline cars, when gasoline is priced much higher.

There will, of course, be more fuel-efficiency improvements. There is an enormous potential, but right now these improvements are mostly being countered by more power and bigger vehicles in the United States and in Europe. So again, technology is enormously promising, but it is not being used to decrease energy use or CO_2 emissions. We build 24-valve cars to save fuel; instead all of that technology is being used to boost power.

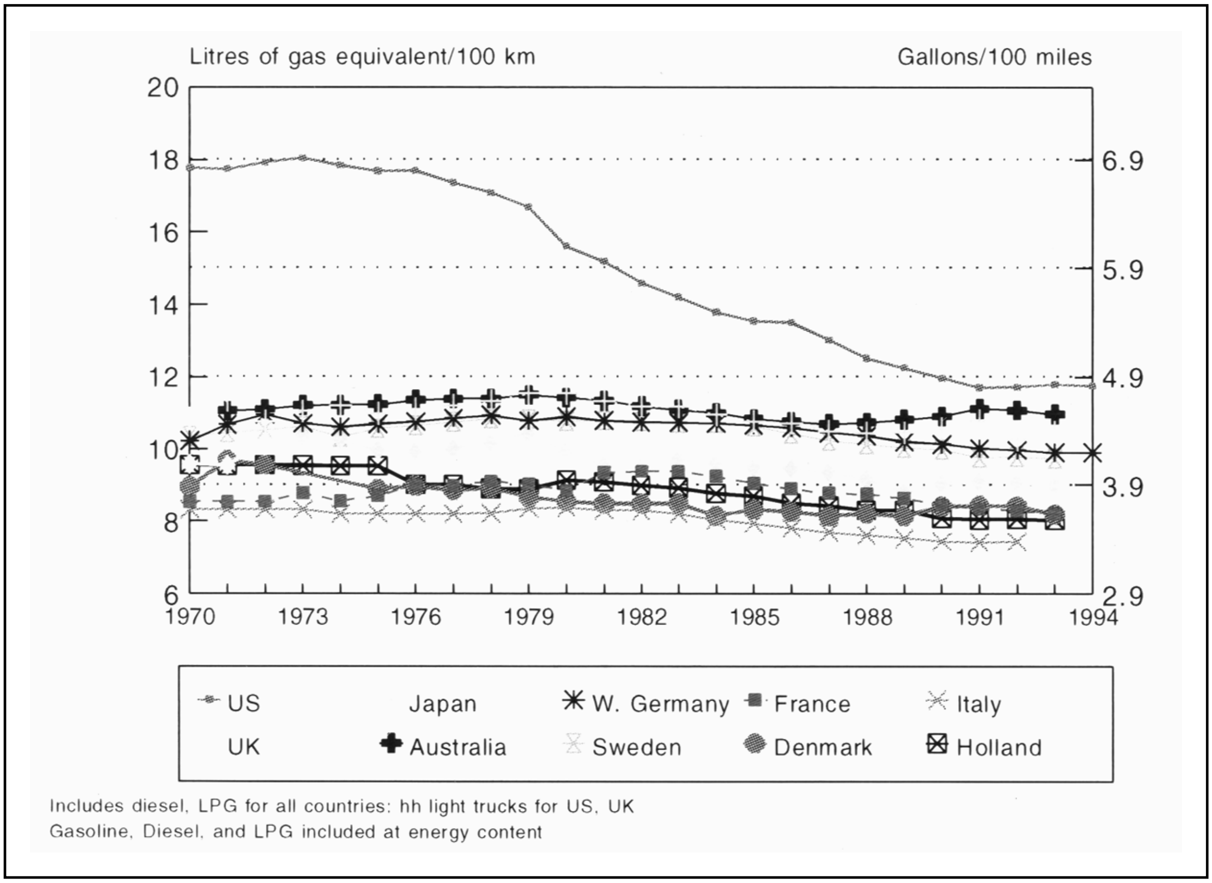

Figure 19-5. On-road fuel use per 100 kilometers by country.

Alternative fuels intended to decrease CO_2 release have also produced mixed results. We subsidize ethanol production from corn in the United States at the equivalent of 60–80¢ a gallon gasoline equivalent, about the wholesale price of gasoline itself. This ethanol is sold as a renewable fuel, but there is evidence that suggests that the gasoline and diesel burned on farms and in factories to produce the ethanol may lead to a greater CO_2 release—what I call "closet CO_2"—than if we simply used these fuels directly. Because of this subsidy in the name of renewable fuels and clean air, users see no incentive to change how or how much they use their cars nor to seek less fuel- intensive cars, all of which contribute directly to solving the problems that farm-based ethanol allegedly will mitigate.

This situation is unfortunately one of the grounds for my pessimism. The United States loves to promote "solutions" whose basis is entirely hidden subsidies. While I have some faith in alternative fuels (natural gas, ethanol from true biomass grown in forests) and in the potential for electric drive (such as Chrysler's recently announced gasoline-to-hydrogen fuel cell), I cannot see these alternatives succeeding as long as gasoline and diesel remain cheap—relative to the unpaid social costs of using them.

Another is that we are unwilling to price gasoline such that reasonable alternatives are cost competitive. As a result we get nowhere with establishing a viable alternative fuel market, and that is the experience worldwide. Strong market signals are

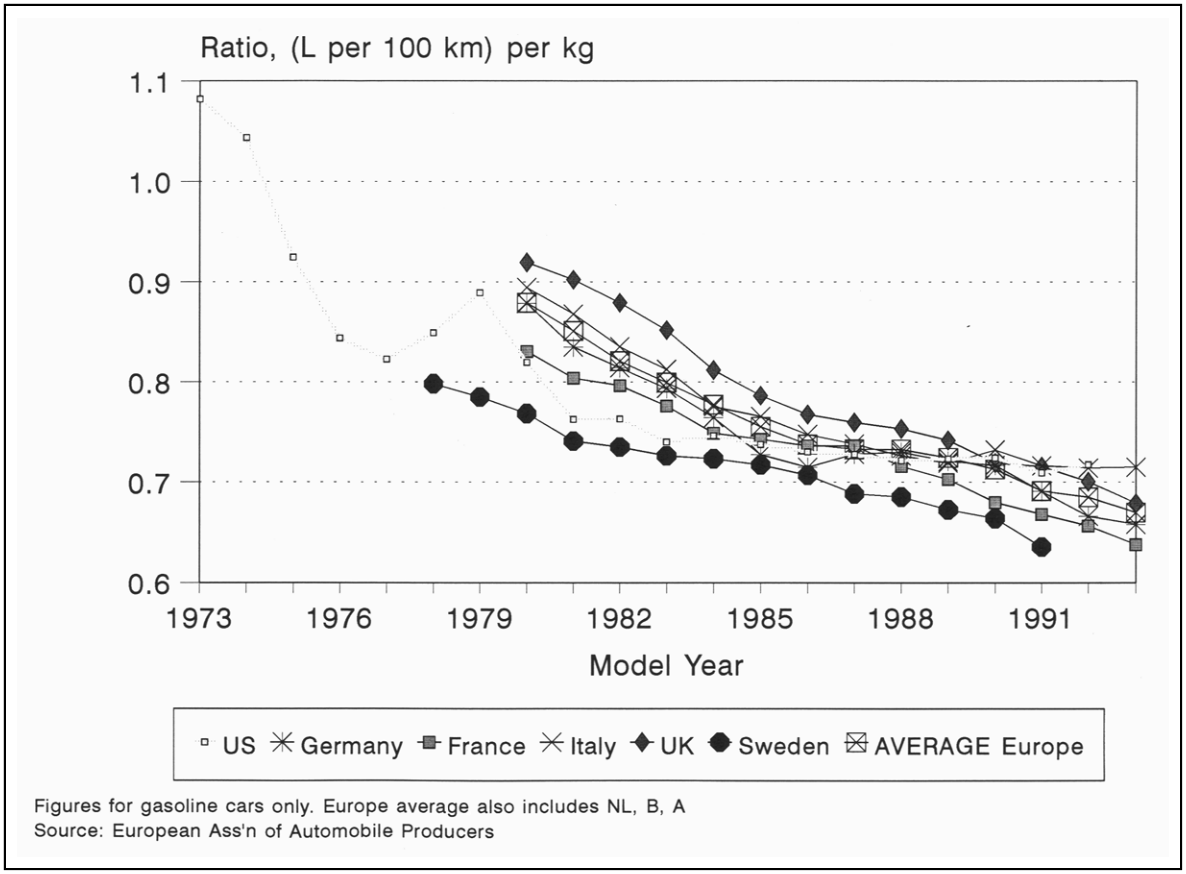

Figure 19-6. Test average fuel use per 100 kilometers per unit mass.

needed to provoke significant changes in which fuels we used, and how well we use them.

Fuel use for freight could also be restrained significantly. The biggest improvements in freight transport would occur if trucks were more fully loaded and traveled shorter distances. If the fuel costs rise, the cost of trucking will rise, and people will begin to choose closer suppliers because distant suppliers will think twice about offering free air and truck delivery overnight with the purchase of a $2,000 computer. However, it is important to note that in the last five years the United States has been reducing the energy and the CO_2 per unit of freight shipped.

With information technology reducing our need to travel, mobility could be reduced with no loss of freedom. On the other hand, information is probably the most important reason why we are getting richer, and so while we don't need to travel as much in order to make the money, we find that we are traveling a lot more when we want to spend the money.

In other words, without a major breakthrough in a no-CO_2 fuel like hydrogen produced from non-fossil or truly renewable sources, or a major breakthrough in the area of very, very low energy vehicles, we will not solve this CO_2 problem technologically. This is not to say that the Partnership for New Generation of Vehicles in the United States or the equivalent programs in Europe and in many European auto compa-

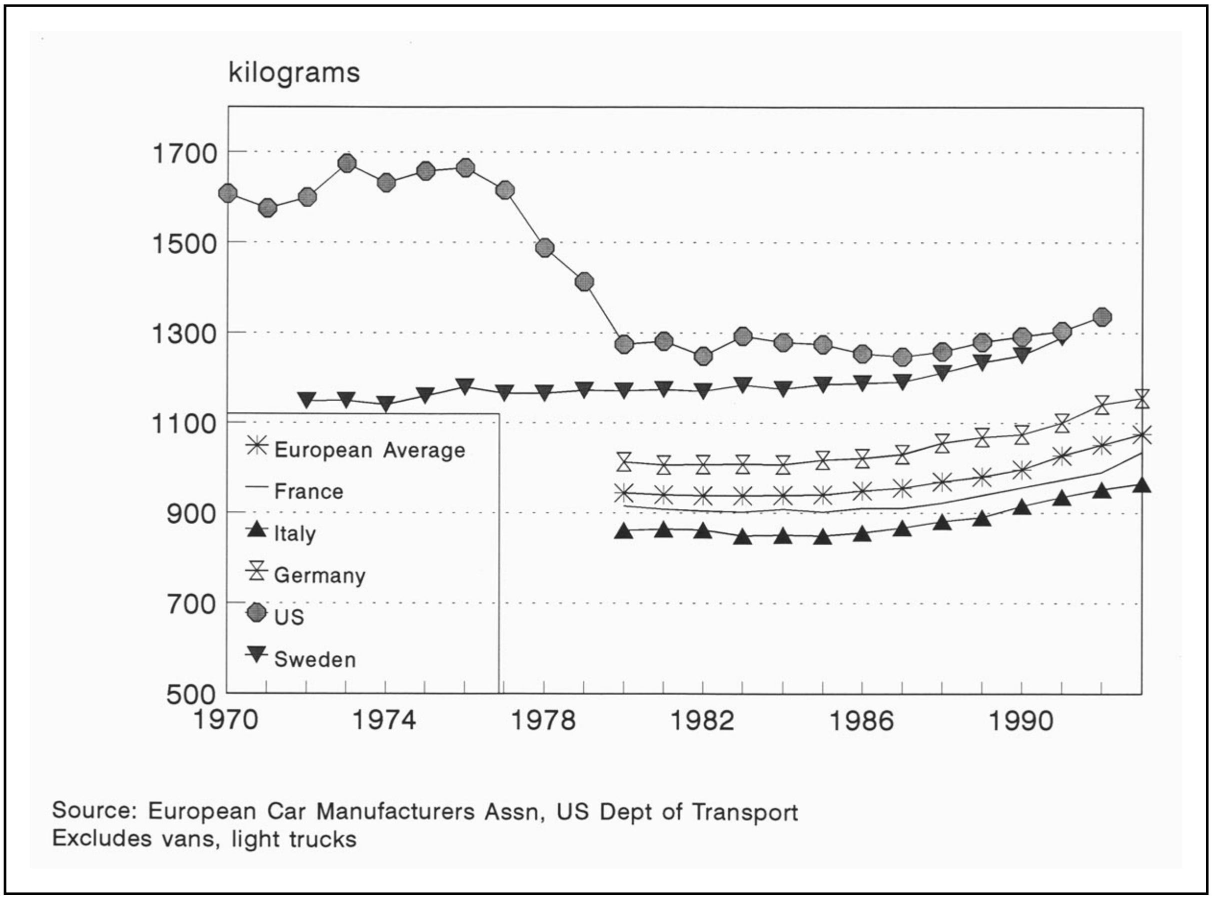

Figure 19-7. Average new car mass in Europe and the U.S.A.

nies might not succeed. But this is a gamble because in the past we have banked only part of our technology improvements as bottom-line lower energy or lower CO_2 .

Full-cost pricing

The U.S. approach to constraining emissions focuses on technology and not on behavior. Pricing as an important strategy is left out much to the consternation of the rest of the industrialized world. Indeed, on the other hand, all the European governments are now talking about full-cost pricing. What that means is the following: Consider the real health damage today from people breathing the air in Los Angeles. Based on disease rates, the resulting medical bills, and the fuel used, the health cost equivalent per gallon of fuel consumed is about 60¢ a gallon, very close to the wholesale price of gasoline in Los Angeles. Of course as cars get cleaner these costs will fall; in some regions the costs are minimal, too. Nevertheless the principle often repeated by the Organization for Economic Cooperation and Development, which houses the International Energy Agency where I work and from where this broadcast emanates, is "The Polluter Pay Principle": The most efficient way to deal with the pollution problem is to tax the pollution itself.

In other words, what economists have been telling us for decades is that we should all be paying that 60¢ a gallon. Instead Angelenos pay a lot less. After all, Los Angeles, as a city, built what is called the "No Regrets Light Rail Line." It is called the "No Regrets" because I have no regrets if you take it to work! My benefit if you take the street car to work should compensate my share of the cost to build and operate it. It was paid for by a small gasoline tax. Nevertheless, if you calculate the costs to move a passenger on the "No Regrets Line", including all the capital costs, you get something like \$8–18 per trip. So Los Angeles has said it is worth a substantial amount from collective general tax funds—\$8–18 per trip—to get someone to take a streetcar, presumably to lessen congestion and to improve health and safety conditions, but no one is willing to burden automobiles directly with these costs.

Is that the value to Los Angeles of reducing car trips? How many of the new users would otherwise have taken their cars? Imagine if each person using a private car had to pay this extra "declared value" of, say, only \$8 to use the car (roughly what a day's parking costs). Certainly some would be deterred from driving, and would walk or take public transportation; over the longer run, others might relocate. The point is not that everyone or even a majority would change radically, but that significant changes would occur. After all, even a 10% shift out of cars to busses or the "No Regrets" line would essentially double the share of non-car trips to work in Los Angeles. Done on existing lines, this would improve transit incomes enormously!

Full-cost pricing is not easy. Although Europeans do not really know exactly the equivalent costs of externalities, they know that these are considerable and that users of cars, trucks, and other transport modes should pay for these common-subsidy benefits. Indeed, it may be that gasoline is too heavily taxed in Europe, while kilometers driven are under-taxed. And your car insurance? I would argue that at least half of that is proportional to how much you drive, yet most pay a fixed sum for collision and liability. If my own collision and liability premiums were expressed on a per kilometer basis (about 3¢/km) and then converted at 30 miles per gallon to an equivalent per gallon basis, they would come out to a "tax" of nearly \$1.50 a gallon! So distorted is our way of paying for transportation today.

With these kinds of distortions, I believe we need a more price-responsive transport system. The potential changes are large. So to me, full-cost pricing (or even partial external-cost pricing) is one of the first steps in constraining CO_2 emissions, but we all know that this is almost impossible to bring about. For example, several years ago local authorities proposed an experiment for the Oakland–San Francisco Bay Bridge in California, to charge a higher toll at peak traffic hours to encourage car pooling and better distribute the bridge usage. Makes sense, doesn't it? It took two years to find a state legislator who was willing to sponsor the legislation.

And look at how the airlines protested when the government wanted to raise landing fees and other collective costs of using airports, indignant that the traveler should have to pay for the costs he or she incurs. In America, in particular, there is a strong aversion to using pricing to influence transportation patterns.

We prefer administrative measures, but these are very easy to thwart. In France just before the election, everybody is exonerated for their unpaid parking tickets. In the United States we force large companies to institute carpool programs in clean-air nonattainment areas. To meet their 20% reduction targets, some companies suggest employees go to a four-day work week; but then employees drive as much or more on the fifth day, not the responsibility of the company.

Consider HOV (high occupancy vehicle) lanes. If you calculate their cost, make a liberal estimate for the number of new carpools they attract, presume all of these represent formerly single-drivers, and take into account the slower traffic the remaining drivers face, you get the "No Regrets" system providing some pollution and CO_2 relief at very high costs per gallon saved. But local communities pay very little for these HOV lanes; federal funding, aka pork barrel, provides the bulk. This is hardly a way to engineer a slow but deliberate path to a low-CO_2 transportation system.

The good news is, if we mature enough to do transport policy right, then we can deal with CO_2 rather easily, because the kinds of things that make sense to defeat congestion and pollution will change transportation modes, change vehicles, change fuels, and even change lifestyles. Why? Because if we had to pay what it really costs to get into the city at rush hour, or to spew out all that dark smoke, we would make other choices about how you travel. Every time this sort of experiment is run, whether it is in a rich country or a poor country, we always see big changes. Most see the hidden costs of CO_2 as small compared with other externalities. In the United States, that means if we shed our fears of using pricing as a primary (but not exclusive) instrument in dealing with transportation problems, we are likely to see substantial long-run reductions in total traffic and fuel use over what we'd otherwise expect for reasons related solely to direct transportation costs and problems. This could give us as much as a 20% reduction in emissions from cars and trucks even before we consider making vehicles themselves more efficient and looking for fuels with lower CO_2.

United States needs to lead

The United States generates the most CO_2 per capita from transportation of any nation, although other countries are rising and transport's share of CO_2 generation is rising everywhere (Refer back to Figure 19-1). The United States also leads the world's energy and automotive industries. Therefore we must lead in attacking transportation and CO_2 problems. There are responses to this situation. The World Energy Council has analyzed incentive scenarios that might actually reduce automotive CO_2 by a factor of 50 or 60% from our 50-year projections. The problem is not that we don't know of mechanisms and technologies to stabilize or reduce CO_2, it is that we have no feedback in our economic systems to do so. We have no social feedback; nobody cares enough to want to do so. Only in the Nordic and some European countries are they beginning to tax CO_2 and tax driving more. Car makers are looking at low energy cars and low carbon fuels, but there is no market for these yet, partly because 12 years ago we were paying 2.5 times more in real terms for fuel than we are today. In 1981, the Ford Motor Company thought that by 1985, they would selling 35 mpg cars. But the price of fuel crashed. German auto makers and (unilaterally) Volvo have made pledges to reduce by 25% fuel use per kilometer in the cars they sell. The Danes have proposed a graduated yearly car registration fee that rises with car fuel consumption per kilometer.

The trouble is, of course, that everybody is waiting for the United States to act. Fuel costs four times in Paris what it costs in the United States. Europeans were incredulous that we thought to use the strategic petroleum reserve to compensate a 20¢-per-gallon price increase and strongly rejected gas taxes of a few cents per gallon. Our squabbles over the Clinton gasoline tax of a few cents per gallon, or the Bush proposal of 9¢ per gallon in 1990 were viewed by Europeans as ludicrous. I remember one day in 1993 when the Ministry of Transport in Estonia asked me whether they thought that a tax of 20¢ (U.S.) per liter on gasoline (at the time there were no taxes) was reasonable, given that such taxes at the time ranged from 25¢ per liter in Poland to 75¢ per liter in most of Western Europe. Given the purchasing power of the Estonians at the time and the differences in the real value of currencies, this tax was more like 40¢ per liter or $1.60 a gallon to Americans. That very day in the United States, our Senate rejected a tax proposal of slightly under 8¢ per gallon. I was ashamed.

That is really the challenge for the United States and the reason that I am so worried. The solutions, be they technological or social or economic, are all there, but if I look back over 20 years at the way we have reacted to the energy problems, I am worried that we really don't have the internal consistency to be able to take those solutions. I hope things change, but I am pessimistic that our sociopolitical systems are capable of solving this problem. Carbon dioxide need not be an environmental threat, but the inability of the United States to take it on suggests that only after CO_2 has become a major problem, i.e., when it is almost too late, will the United States act.

Food insecurity

Hal M. Kane

Whether food production can keep pace with population growth and meet the needs of the currently undernourished is one of the most fundamentally important issues in the world, and one that is likely to lie beneath many international security concerns in the future. Since the mid-eighties, several agricultural trends that have been constantly positive throughout modern history have reversed and become worrisome. For example, world grain production, which had increased both absolutely and on a per capita basis through history has rolled over (See Figure 20-1) while the world population has continued to increase.

In 1950, the average grain production per person was 247 kilograms. It peaked in 1984, at 346 kilograms, after the impressive growth of the Green Revolution. But by 1995 per capita grain production had fallen back below 300 kilograms to just 293 kilograms per person. Even the absolute quantity of grain produced had stopped rising, with no more produced in the mid-nineties than had been produced in the mid-eighties—about 1,680 billion tons in 1986 and 1995 alike.

The following brief article mentions some of the important trends in the world

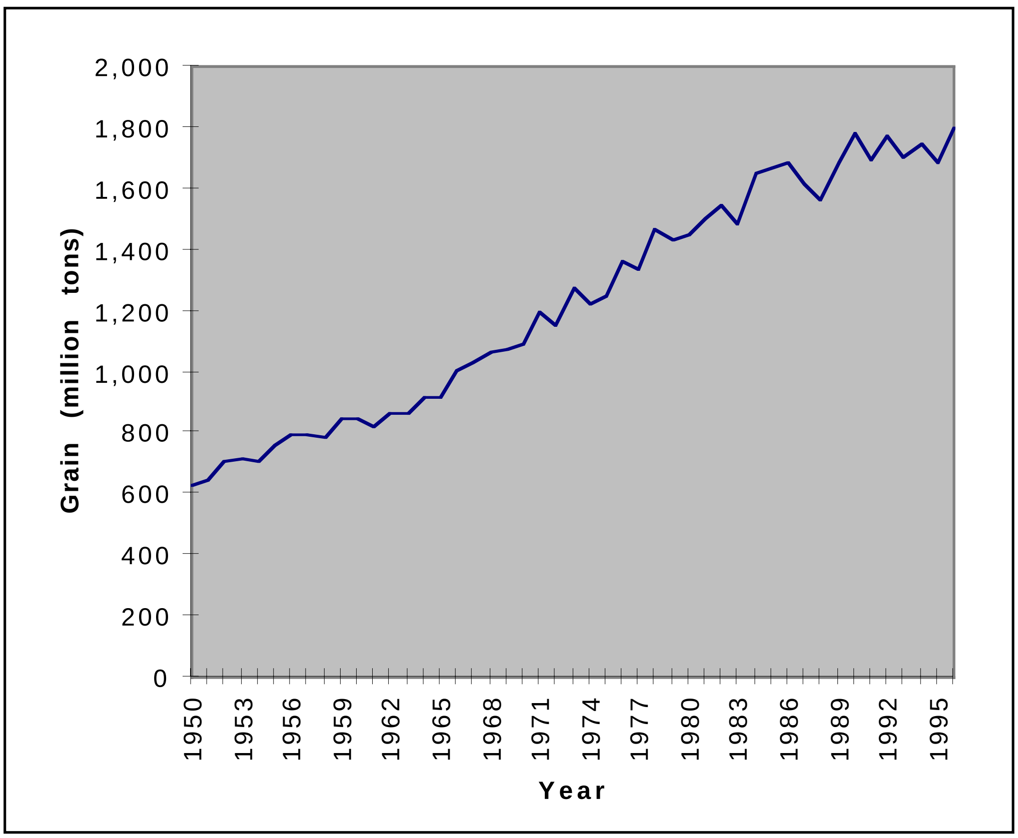

Figure 20-1. World grain production.

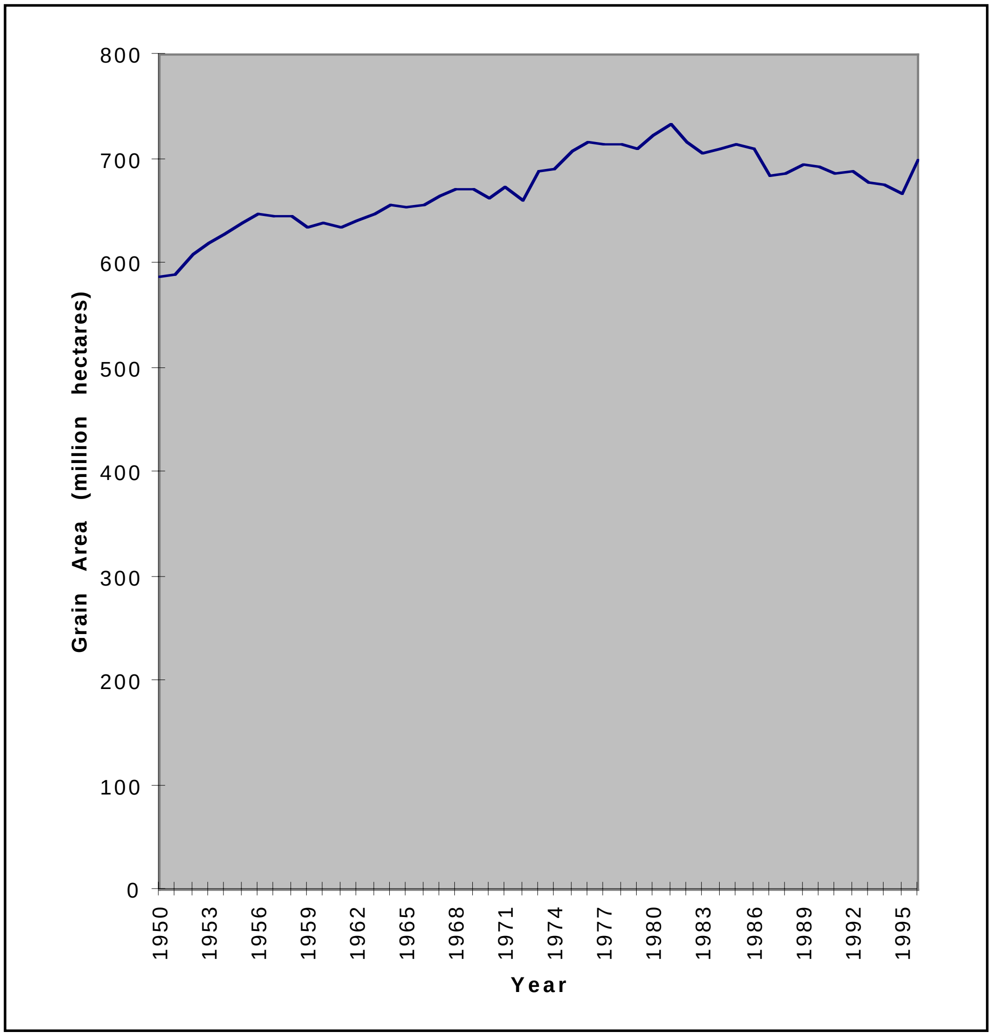

Figure 20-2. World area used for grain production.

food/population equation and indicates caution and the probability of international stress based on deficient food supply. A far more detailed discussion of these trends can be found in the book *Full House: Reassessing the Earth's Population Carrying Capacity* by Lester R. Brown and Hal Kane (1994).

The land area used to grow grain

For all of history, the amount of land used to grow grain has increased. From 587 million hectares in 1950, it rose quickly, for example, to a peak of 732 million hectares in 1981 (Figure 20-2.). Over the past 16 years, however, for the first time ever, the amount of land in grain production has decreased. By 1995, total grain harvested area was down to 665 million hectares. On a per capita basis, this was a drop from 0.23 hectares per person in 1950 to 0.12 hectares per person in 1995—a drop of one-half.

The U.N. Food and Agriculture Organization (FAO) says that an area of land about the size of Ireland is lost to production every year because of land degradation. An area about that same size is also put into production every year, currently leading to a net constancy in grain harvested area. But, much of the land now used is of poorer quality, either because of agricultural mismanagement or because the better agricultural land is going to other uses, leaving lower quality land that is arid or now being cleared of forest for agricultural use.

This means that in the future ever growing amounts of food will have to be produced without the main historical engine of agriculture expansion—the bringing into production of more land. The burden carried for thousands of years by the cultivation of new areas will now have to be carried by increases in production efficiency or new food substances.

Changing trends in fertilizer use

The agricultural revolution, which started around 1960, depended on a large jump in the amount of fertilizer used by farmers. Fertilizer use grew steeply and was one of the most reliably increasing trends in the world. In 1950, the world used only 14 million tons of chemical fertilizer. The amount had climbed steadily to 146 million tons—more than a ten-fold increase in less than half a century (Figure 20-3.)—up until 1989, but that year saw the first ever major drop in fertilizer use. Fertilizer consumption

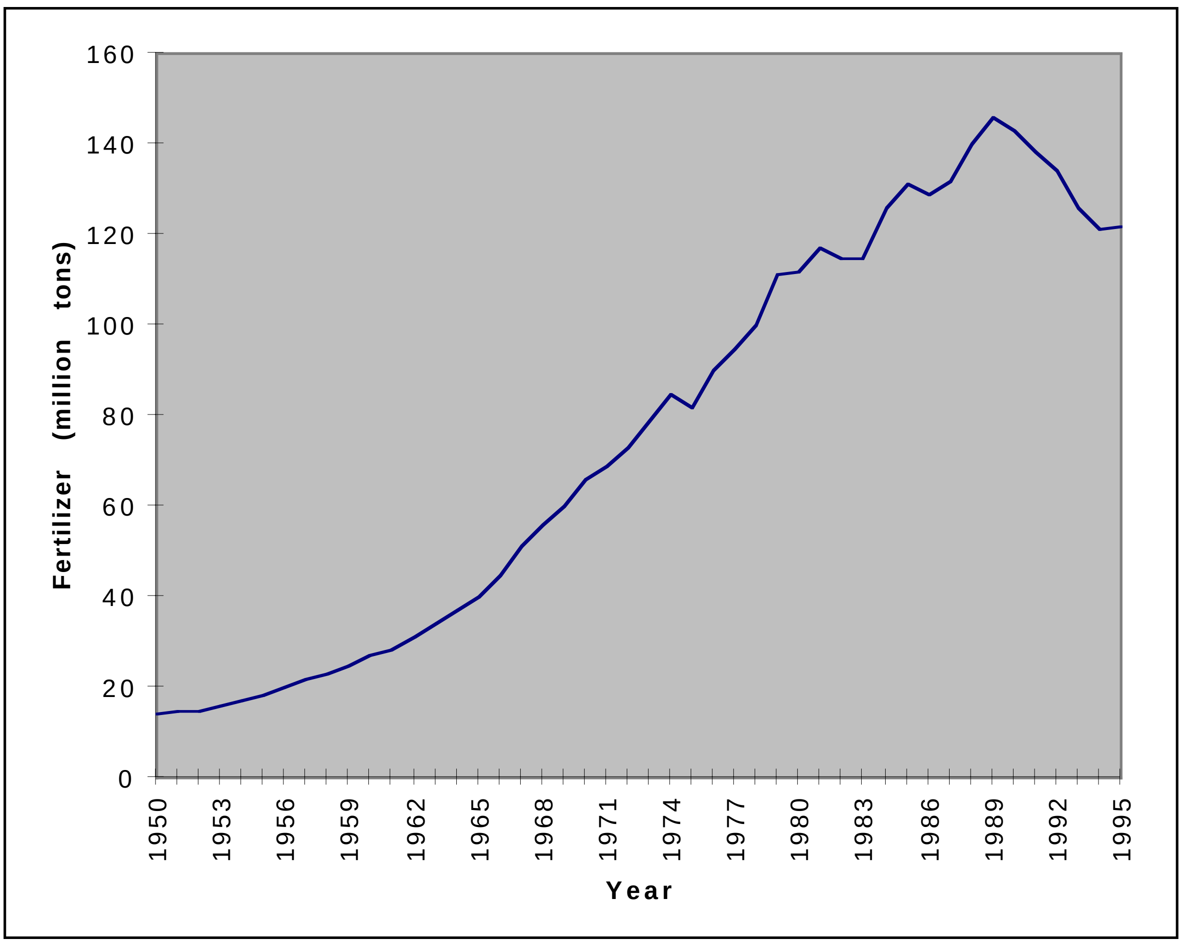

Figure 20-3. World fertilizer use.

fell steadily until 1994, dropping all the way back down to 121 million tons. Since then, fertilizer use has been about flat.

Most of this drop was due to changes in the former Soviet Union. That country had been subsidizing fertilizer use, and the disintegration of the old system did away with much of those subsidies, and fertilizer consumption there plummeted. Because the fertilizer was artificially inexpensive and because Soviet farmers did not know how to use it properly or did not have incentives to use it properly, much of the Soviet fertilizer use had been excessive—farmers had dumped more fertilizer on their fields than could be absorbed.

Even with the former Soviet Union factored out, the world still had a shrinking appetite for fertilizer beginning in the late eighties, and many people believe that the reason is that many fields were reaching a saturation point with fertilizer. Adding fertilizer to a field that has had little fertilizer has a large effect, but adding it to a field that already has had much applied accomplishes less. Once a field has absorbed as much fertilizer as it can, adding more has no effect, or even a negative effect.

Some parts of the world are not using enough fertilizer today, but the number of places that have reached the capacity of their lands to absorb fertilizer has grown substantially along with the historical rapid rise in fertilizer consumption. It now appears likely that fertilizer will be less of an engine in the future than it was in the past for expanding the world's food supply. It joins land as a lost or declining engine, and it leaves the burden of providing more food to other sources.

Irrigation

Another critical resource for expanding the food supply is, of course, irrigation. For every thousand people in the world in 1961, the world irrigated 45.3 hectares of land. And in order to expand the amount of food available, this irrigated area increased, especially during the seventies (Figure 20-4.). But in 1979, irrigated area joined grain harvested area and fertilizer use as another agricultural resource trend that had turned downward. The irrigated area per person fell through the eighties and early nineties, and is now back below the amount of irrigated land per person that the world had in 1961. The 1993 figure is 44.4 hectares of irrigated area for every one thousand people.

Like with quality grain land, people tend to settle near the places where irrigation is easiest—near rivers and lakes, for example. But once this land is used, people are forced to farm areas that are poorer in fertility and water. The costs of irrigation rise. Meanwhile, the number of people requiring food is rising constantly. In the future, increasing amounts of food will have to be grown despite the decline in per capita irrigated area.

The world's fish harvest

Another source of food that increased through all of history and then stopped growing during the eighties is the world's fish harvest. The world's fish harvest in 1950 was only 21 million tons. By 1989 it had grown to 100 million tons, almost a five-fold increase (Figure 20-5.). But that level marked the historical end to growth in the fish

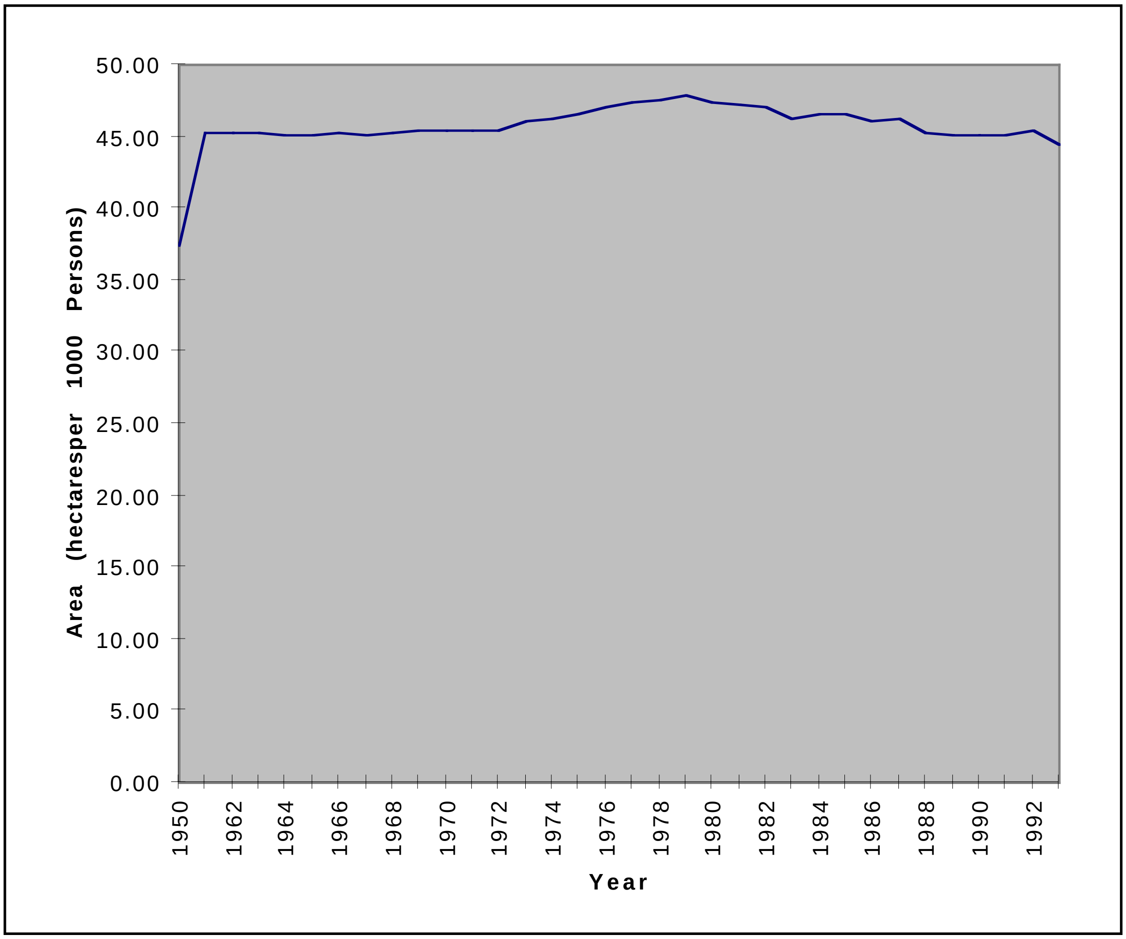

Figure 20-4. World irrigated area per 1000 persons.

harvest. World fish catch has remained approximately constant since then, and is now slightly over 100 million tons. Marine scientists, including those of the U.N. Food and Agriculture Organization (FAO), had long forecast an upper limit to the fish harvest, and many of them had estimated that approximately 100 million tons would mark that limit.

Aquaculture still has the ability to raise the world's fish harvest, but aquaculture requires the use of grain for feed that could instead be eaten directly by people, and it also requires land and water for the growing of fish. Nevertheless, aquaculture is the only remaining means to increase fish harvests FAO and most other organizations do not expect the natural harvests of the oceans and lakes and rivers to rise very much in the future.

The fish harvest is interesting on another level as well. With most foods, technology can be used to increase harvests. But with fishing, improved technologies such as better fishing boats actually cause part of the problem. Powerful fishing boats take fish faster than the fish can reproduce and so have caused the stocks to decline. Better fishing technologies only have the potential to reduce the fish harvests of the oceans, lakes, and rivers, not to increase them.

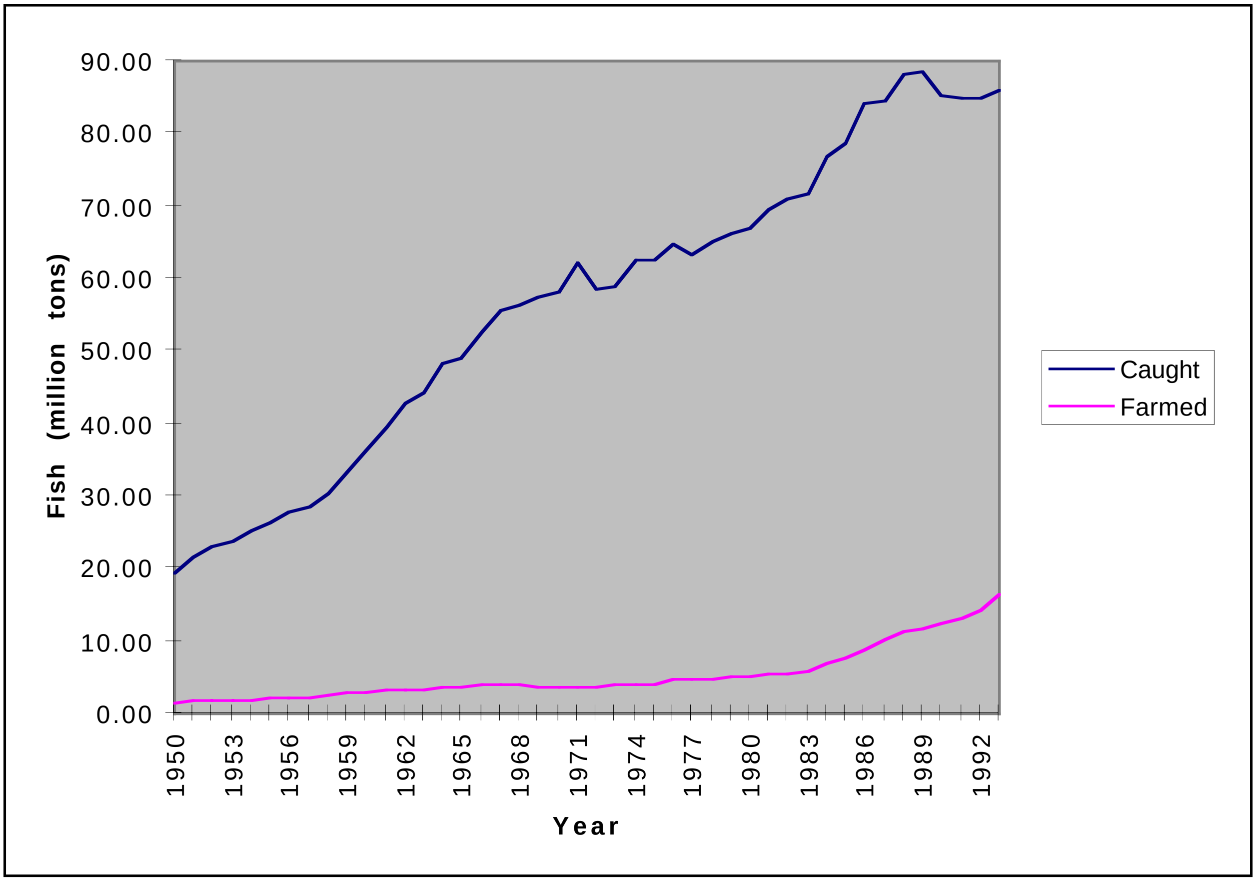

Figure 20-5. World fish caught and farmed.

Technological solutions

The end of growth in grain harvested area, fertilizer consumption, irrigated area per capita, fish catch, and in other trends like declines in the amount of grazing land available leave the burden of increasing food production squarely in the domain of improved technologies.

Technology may indeed solve these problems. There are several differences, though, between the technologies being created today and the task at hand. The inputs of the green revolution—more fertilizer, more water, and new seeds—were global solutions. Any farmer anywhere could fairly simply add more fertilizer and water and get more food. Little education was required, little capital was required, and the work did not have to be tailored to local conditions. New technologies are quite different from this. They are specific: suited to a particular pest or a particular soil or climate. Some of them are expensive, requiring more money than the farmers of Africa, South Asia, and Southeast Asia have. And many of them require training and research on local needs. These new technologies are ingenious; but they are not always suited to local farming conditions, or to the local economy or local culture.

Second, many new technologies are being targeted at expensive crops, because they are the most profitable. On the other hand, the budget of the institutions dedicated to making new seeds and technologies for common crops like grains and roots is not rising, and in some years has shrunk. The Consultative Group for International Agricultural Research (CGIAR), the headquarters of which is housed at the World Bank, has never been adequately funded. Now, at a time when the need for food is growing and when poverty is widespread, the needed funding is not keeping pace.

The problem of hunger may be solvable. But one thing is clear: it will not be solved by accident or by laziness. Rising prices for food are not a miracle solution—there are no miracle solutions. What is called for is hard work, and hard research. Funds will have to be directed toward the CGIAR and other research and training organizations, if food security is to be addressed. Too many people brush aside the issues of food security, assuming that "technology" will solve the problems, even though they cannot say which technologies will do so, nor who will design those technologies.

The population side

Another way to fight hunger is to fight poverty and make families more able to buy and grow food. Lessened poverty tends to reduce birth rates, thereby reducing the total demand for food. Fighting poverty has this double benefit, and, of course, is also a priority goal for many other reasons.

In 1994, in Cairo, Egypt, the United Nations Population Conference came up with a set of goals to improve the state of the world's population, both its size and also the quality of people's lives. Food security was not intended as a major goal for these initiatives, but the reality is that they would also serve the purpose of improving food security. The initiatives include raising immunization rates, raising literacy rates, especially for young girls, making birth control available, improving human rights records, getting more access to health care, and in general, fighting poverty and raising the quality of life. There is no reason not to move forward with this work.

In fact, there is reason for some optimism. For example, immunization rates 10 years ago were only about 20% for children in developing countries. Today, the rate is about 80%. In a short number of years, and with a very manageable amount of money, the world's children became far more protected from many of the world's leading causes of death and disability. Birth rates are lower in countries that have low child-mortality rates, and so success with immunizations also becomes a success in dealing with population growth, and hence also a success for food security. In fact, it is reasonable to call this a national security success, since improved food security, reduced over-population, and more stable families all contribute to social stability and general security.

International security

Food shortages can destabilize governments and cause other political disruption in several ways.

First, they threaten some of the largest and most important governments in the world. China is projected to add almost half of a billion more people over the next 30 years, but is losing about 1% per year of its grainland to industrialization and urbanization because of its very rapid economic growth, and faces severe water scarcity in many regions. Already, these changes have added substantially to the "floating population" of between 100 million and 160 million Chinese, many of them former farmers who no longer have the water or land to farm. This massive migratory population, larger than the entire population of Japan, could destabilize China if these people can not find food, employment, and housing. These pressures are strong in China, but they also exist in India, the world's second most populous country, and in north Korea, Russia, the Former Soviet states, and many African countries.

The world today has few wars between states. Instead there are many wars within countries that have fallen into civil disarray. Issues of hunger, scarcities of farmland and water, and other social and environmental problems drive these internal wars and greatly increase the destruction and misery that they cause.

Rwanda used to be Africa's most densely populated country and the second most densely populated country in the world. It suffered extreme scarcity of both farm land and irrigation water. The pressures contribute to the ethnic jealousies that led to fighting there. Similar situations exist in both Haiti and Somalia, extreme overpopulated and the lack of viable agricultural resources. These issues mix together, linking population, food, health, and political and military security, into a complex mess.

Second, food scarcity becomes an international security issue as well. Food scarcities reach across national borders and cause rising food prices everywhere. Since grain markets are global, China's buys bid up prices for others, for the United States and for poorer countries alike. In this way hunger enters countries other than the ones initially experiencing the food shortages. Food scarcity is a threat that can cross national borders.

Third, when people cannot feed their families at home, they begin to look elsewhere. Migrations like the internal migration in China can become international migrations and threaten the borders of neighboring countries Southern Europe, for example, is increasingly a destination for hungry people from Africa, to mention only one such situation.

Food security and the solutions to it are not normally brought into discussions of national security, but they should be. Dealing with these issues will reduce the tensions that contribute to instability. To conclude on a positive note, dealing with hunger is less expensive than dealing with conflict. And, dealing with hunger and poverty generates economic growth in both the short and long terms.

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Emerging infectious diseases

Frederick A. Murphy

From experience, we know that many different elements can contribute to the emergence of a new infectious disease: these include microbial/virologic determinants (such as mutation, recombination, natural selection, evolutionary progression of the pathogen), natural influences (such as ecologic, environmental, and zoonotic influences on the pathogen), and factors pertaining to human activity (such as personal behavior and societal, commercial, and iatrogenic factors affecting the pathogen). New infectious diseases appear to be emerging with increasing frequency, as suggested by published reports of cases, outbreaks, and epidemics, and by the rate of identification of new pathogenic microorganisms and viruses. The list of newly emergent pathogens of humans and animals is impressive, indeed (Tables 21-1 and 21-2), and is seemingly prophetic of more to come in the future. There are several reasons why emergence of new pathogens seems to be accelerating. The global human population has continued to grow inexorably, bringing increasingly larger numbers of people into close contact. There have been successive revolutions in transportation, making it possible to circumnavigate the globe in less than the incubation period of most infectious diseases. Ecological changes brought about by human activity are occurring at a rapidly accelerating rate. Additionally, now, bioterroristic activities, supported by rogue governments as well as organized amateurs, involving "high-tech" as well as "low-tech" threats, are clearly increasing in scope and scale.

Note an initial tension between national security as usually understood, with its focus on national defense and force projection, and the fundamental nature of infectious disease, which is regional and global in scope, especially given modern international transportation networks. Note also the possibility that, while infectious diseases as a whole may not be a clear national security concern (or, as Allenby (Allenby: Definition) discusses, appropriately researched or managed by the security apparatus), there has always been a concern with infectious disease whenever U.S. military personnel must serve or intervene overseas. Taken together, these two observations suggest that what is required in this area is not a radical departure from past practices, but rather an evolution and strengthening of existing ones (particularly funding practices). What these are, and how they may be addressed and modernized, is discussed in the next two sections.

The "discovery-to-control continuum"

Given the reality of the threat, initial investigation at the first sign of the emergence of a new disease must focus on practical characteristics such as mortality, severity of disease, transmissibility, and remote spread, all of which are important predictors of epidemic potential and societal risk. Clinical and pathologic observations and preliminary agent identification (the new realm of molecular biology) often provide early clues. From this point, various elements of a "discovery-to-control continuum" are usually called for. The continuum starts with (1) discovery, the precise recognition of a disease in a new setting, and continues through (2) epidemiologic field investigation, (3) etiologic investigation, (4)

Table 21-1. Some important new, emerging and re-emerging human virus pathogens.

*Crimean-Congo hemorrhagic fever virus** (tick-borne; severe human disease with 10% mortality; widespread across Africa, the Middle East and Asia)
*Dengue viruses** (mosquito-borne; the cause of millions of cases of febrile disease in the tropics, dengue hemorrhagic fever, a life-threatening disease, especially in children)
Ebola, and Marburg* viruses* (natural reservoirs unknown; Ebola and Marburg viruses are the causes of the most lethal hemorrhagic fevers known)
Group A, B & C rotaviruses (rotavirus enteric disease is the second leading cause of death in infants in the world)
*Guanarito virus** (rodent-borne; the newly discovered cause of Venezuelan hemorrhagic fever)
*Hantaviruses** (rodent-borne; the cause of important rodent-borne hemorrhagic fever in Asia and Europe.
Hepatitis C virus (newly identified; the cause of much severe, chronic liver disease in the United States)
Hepatitis delta virus (an unusual "helper" virus that makes hepatitis B more lethal)
Hepatitis E virus (newly identified; the cause of epidemic hepatitis, especially in Asia; recently recognized as widespread along the U.S. / Mexico border; the infection has a high mortality rate in pregnant women) *Hepatitis G virus* (newly identified; the cause of a small proportion of transfusion-related hepatitis worldwide)
Human herpesviruses 6 & 7 (newly identified; the cause of a substantial proportion of febrile disease in children)
Human herpesviruses 8 (newly identified; associated, possibly causally with Kaposi's sarcoma)
Human immunodeficiency viruses, HIV1 and HIV2 (the causes of AIDS, still emerging in many parts of the world)
Human papillomaviruses (over 70 viruses; some associated with cervical, esophageal, and rectal cancers)
Human parvovirus B19 (the cause of roseola in children; a possible cause of fetal damage when pregnant women become infected)
Human T-lymphotropic viruses (HTLV1 and HTLV2) (the cause of an adult leukemia and neurologic disease, especially in the tropics)
Influenza viruses (the cause of thousands of deaths every winter in the elderly; the cause of the single most deadly epidemic ever recorded—the worldwide epidemic of 1918, in which over 20 million people died)
Japanese encephalitis virus (mosquito-borne; very severe, lethal encephalitis; now spreading across Southeast Asia; great epidemic potential)
*Junin virus** (rodent-borne; the cause of Argentine hemorrhagic fever)
*Lassa virus** (rodent-borne; a very important, severe disease in West Africa; imported into a Chicago hospital in 1990)

Table 21-1. (Continued.)

*Machupo virus** (rodent-borne; the cause of Bolivian hemorrhagic fever, recent outbreaks after many years of quiescence)
Measles virus (re-emerging in several countries because of poor vaccine coverage)
Norwalk and related viruses (major causes of outbreaks of severe diarrhea)
Polioviruses (the cause of poliomyelitis; still an important problem in developing countries of Africa and Asia; targeted by WHO for worldwide eradication by the year 2000)
Rabies virus (transmitted by the bite of rabid animals; raccoon epidemic still spreading across the northeastern United States; new coyote epidemic spreading in south Texas)
*Rift Valley fever virus** (mosquito-borne; the cause of one of the most explosive epidemics ever seen in Africa)
Ross River virus (mosquito-borne; cause of epidemic arthritis; has moved across the Pacific region several times)
Sabiá virus (rodent-borne; virus from Brazil; newly discovered cause of hemorrhagic fever, including two laboratory-acquired cases)
Sin Nombre virus (emerging as the cause of the severe, often fatal acute respiratory distress syndrome in western regions of the United States) *Venezuelan encephalitis virus* (mosquito-borne; cause of recent major epidemics in Central and South America)
*Yellow fever virus** (mosquito-borne; one of the most deadly diseases in history, great potential for urban re-emergence) *[* the viruses that cause hemorrhagic fevers in humans*]

diagnostics investigation, (5) focused research, (6) policy and marketplace matters, (7) technology transfer, (8) commercialization, (9) training and clinical outreach, and (10) formalization of disease control organization, nationally and/or internationally. Of course, not all of these elements are appropriate in every emerging disease episode. Decisions must be made and priorities must be set: "We can do this, but not that"; "What is the minimum that must be done to deal with this disease outbreak in this given circumstance?"

This "discovery-to-control continuum" deserves further review, as the basis for planning future interventive strategies pertinent to all potentially emergent diseases. At one time this review would have been rather simple surveillance leading directly to control: identify the new disease, learn its nature, set in place a prevention or control scheme to deal with it. But, along came HIV/AIDS, the ultimate case where surveillance and control have gone separate ways. In the United States, more and more sophistication in AIDS surveillance has not led to satisfactory prevention and control programs: in fact some people say that the exhaustive surveillance system has become a mask hiding failures in prevention and control programs. Globally, where not as much has been spent on HIV/AIDS surveillance, the same separation has occurred, but the failures in prevention and control programs have many other causes, as well. In both settings, the media, politicians, and the concerned public have stepped in and have attacked the citadel: "Your vaccines led to the conquest of smallpox, and to a great reduction in

Table 21-2. Some important new, emerging and re-emerging virus pathogens of animals.

African horsesickness viruses (mosquito-borne; a historic problem in southern Africa; now becoming entrenched in the Iberian peninsula; a major threat to horses worldwide)
African swine fever virus (tick-borne and also spread by contact; an extremely pathogenic virus; recently present in Europe and South America; a major threat to swine in North America)
Avian influenza viruses (spread by wild birds; a major threat to the poultry industry of the United States and Mexico)
Bluetongue viruses (*Culicoides*-borne; the isolation of several strains in Australia has become an important nontariff trade barrier issue)
Bovine spongiform encephalopathy agent (recognized in 1986; the cause of a major epidemic in cattle in the United Kingdom, resulting in major economic loss and trade embargo; recently identified as the cause of human central nervous system disease, variant Creutzfeldt–Jakob disease)
Canine parvovirus (a new virus, having mutated from feline panleukopenia virus; the virus has rapidly swept around the world, causing a pandemic of severe disease in dogs)
Chronic wasting disease of deer and elk agent (a spongiform encephalopathy agent of unknown source, discovered in captive breeding herds in the United States)
Dolphin, porpoise, and phocine (seal) morbilliviruses (epidemic disease first identified in 1988 in European seals was first thought to be derived from a land animal morbillivirus, such as canine distemper or rinderpest, but now it is realized that there are several important, emerging pathogens endangering these species)
Equine morbillivirus (a new virus, the cause of fatal acute respiratory distress syndrome in horses [and humans], in Queensland, Australia, in 1994; recently traced to bats–flying foxes)
Feline immunodeficiency virus and simian immunodeficiency viruses (important new viruses, the one affecting cats in nature and the other serving as an important model in AIDS research)
Foot-and-mouth-disease viruses (still considered the most dangerous exotic viruses of animals in the world because of their capacity for rapid transmission and great economic loss; still entrenched in Africa, the middle East, and Asia)
Lelystad virus (mystery swine disease) (a new virus, causing an important disease, porcine reproductive and respiratory syndrome [PRRS] in swine in Europe and the United States)
Malignant catarrhal fever virus (an exotic, lethal herpesvirus of cattle; an important nontariff trade barrier issue throughout the world)
Myxoma virus (used to control rabbits in Australia, but with diminishing success; now a proposal has been advanced that genetically engineered myxoma virus carrying a gene for a sperm antigen be distributed to sterilize infected surviving rabbits)
Rabbit hemorrhagic disease virus (was being investigated as new way to control rabbits in Australia, but then escaped and is spreading rapidly across the continent)
Rinderpest virus (still considered very dangerous with potential for causing great economic loss; still entrenched in several regions of Africa)

polio, measles, rubella, mumps, and hepatitis B, so why cannot you do the same with HIV/AIDS?" We know the scientific answer to this problem, but we have not successfully explained it to the public.

Today, as more examples are plugged into the model "discovery-to-control continuum," it seems to become more and more complex—nevertheless, there is value in seeking the common lessons from our response to HIV/AIDS, dengue, variant-Creutzfeldt–Jakob disease (v-CJD), Ebola, and other emerging disease episodes. This is particularly critical given recent examples of "species jumping" of viruses and microorganisms (Table 21-3) that pose obvious difficulties. The more examples plugged into the model continuum, the more one is struck by the gap between what is and what might be.

The continuum moves from the perspicacious sphere of discovery, to the scientific area of risk assessment, to the nonscientific, political area of risk management. When one reflects on specific disease emergence episodes over the past few years, one is first struck by the importance of the scientific base upon which public health response depends. This base was established by Pasteur and his colleagues in the founding days

Table 21-3. Recent "species jumping" of viral pathogens.

Year	Virus	Disease	Species transfer	Cause
1978	Canine parvovirus	Pandemic enteritis, myocarditis	Cat to dog	Mutation of feline panleukopenia virus
1986	BSE agent	Bovine spongiform encephalopathy	Sheep to cattle to human	Changes in cattle rendering process
1988	Phocid distemper virus 1	Fatal respiratory disease (distemper)	Harp seal to harbor seal	Migration of harp seals due to climatic conditions.
	Phocid distemper virus 2	Fatal respiratory disease (distemper)	Dog to Siberian seal	Contact with terrestrial animals (dogs)
1990	Lelystad virus	Porcine reproductive/ respiratory syndrome (PRRS)	Rodent to swine	?Mutation of rodent virus
1994	Equine morbillivirus	Acute respiratory distress syndrome (ERDS)	Bat (flying fox) to horse to human	?Mutation of bat virus

of medical microbiology and virology and has been extended ever since. The base has been built by laboratory and field investigation, and by the scientific genius, creativity, determination, organizational skills, and other qualities of the first microbiologists and virologists. The base has been built with great breadth and with a fundamental comparative perspective that reflects the fact that the first microbiologists and virologists were all naturalists at heart. The base has been built from a clear motive of bettering the human condition, globally.

What do the initial phases in the "discovery-to-control continuum" look like? The important early role in the continuum of people outside the citadel (the citadel defined as the international community of exotic disease investigators and public health officials) must be recognized—the key players are local clinicians, pathologists (including medical examiners and forensic pathologists), and public health officials, many of whom have not been enamored by their experiences in dealing with those inside the citadel. The important early role of primary diagnostic laboratories and the reference laboratory networks that support them must also be recognized. Additionally, the importance of focused research, aimed at determining the nature of the etiologic agent, the pathogenesis and pathophysiology of the infection it causes, and related immunologic, ecologic (including vector biology, zoonotic host biology, etc.), epidemiologic, and behavioral sciences must be recognized.

In this era of the primacy of molecular biology (and molecular microbiology and virology), it bears reminding that many of the early investigative activities surrounding the identification of a possibly emergent disease must be carried out in the field, not in the laboratory. This is the world of "shoe-leather epidemiology." It is no accident that the logo of the epidemiology program at the CDC is the outline of the sole of a shoe, with a prominent hole worn in it. In the same way, it bears reminding that there is a distinction between the search for an etiologic agent, whether bacterium, virus, protozoan or fungus, and development of diagnostic tests. Recent experiences have illustrated our continuing need for experts who can take a new isolate and turn it into practical tests for the presence of microbial/viral antigen(s), antibodies, and nucleic acids. Here, we need controlled sensitivity, specificity, reproducibility, rapidity, simplicity, and economy, and then we need proof-testing of the whole diagnostics system in the field in the setting of the disease episode at hand.

What do the intermediate phases in the "discovery-to-control continuum" look like? The continuum progresses to the general area of risk management, the area represented not by the question, "What's going on here?," but by the question, "What are we going to do about it?" This phase may include expansion of many elements: (1) policy and marketplace decisions and actions that involve the interface between government and the pharmaceutical industry; (2) technology transfer involving diagnostics development and proof testing, vaccine and drug development and proof testing, sanitation and vector control, and medical/veterinary care activities, and their adaptation to the circumstances of the locale where the disease is occurring; (3) commercialization, where appropriate, of diagnostics, vaccines, therapeutic agents, or provision of alternate sources in quantities needed through "nongovernmental organizations" (NGOs) or developed-country government sources; (4) training, outreach, continuing education, and public education, each requiring professional expertise and adaptation to the special circumstances of the disease locale; (5) communications, at appropriate scope and scale, employing the technologies of the day, such as the Internet, and employing professional expertise that is so often lacking.

It is one of the worst of life lessons that risk assessment does not naturally lead to risk management. It has always been confounding that some diseases touch a public and professional nerve so that efforts to move through the phases of the continuum are well supported, while others equally important in terms of morbidity/mortality stall out. For example, investigation of the 1995 Ebola epidemic in Zaire (now the Democratic Republic of Congo) was well supported internationally (although overwhelmed by patient care needs), but many diseases, usually endemic diseases and those stemming from problems in the food and water supply, are underfunded in developed countries and not funded at all in most developing countries. For example, in the United States, with overwhelming data at hand, it was decided not to spend any money to eradicate the recently imported Asian tiger mosquito, *Aedes albopictus*, even though it is a proven vector of dengue, California encephalitis and yellow fever. Recently, we have seen all vector-borne disease control budgets in crisis.

There is also a life lesson in seeing the arbitrariness in public expectations for success in dealing with emerging disease outbreaks. There is often what I call the "One Riot, One Ranger" level of public expectation. [In the early days of Texas, law enforcement was in the hands of a few Texas Rangers—no matter what the problem, whether it be a bank robbery involving one outlaw or a riot involving hundreds of people, one Ranger was sent in to resolve it.] No matter what the disease outbreak looks like at first, one state or federal epidemiologist is sent in to resolve it. The public expectation is that this person will succeed, because the public has been led to believe that disease outbreaks are fundamentally simple events—the "food poisoning at the picnic" metaphor. It is also the public expectation that if the "first responder" does not succeed, there will always be opportunity to expand the response later. The idea that some diseases move faster than this does not enter the public's mind. Beyond this, all too often there has followed a public sense that if the expanded response does not work, then, "well, we'll just have an epidemic." For example, in 1991, the Pan American Health Organization (PAHO) sent some resources to Peru to deal with the first cholera introduction into the western hemisphere in 75 years. One million cases later, 9000 deaths later, one might wish that the initial response had been more vigorous. Alas, there never is a chance to reconsider, to start over, and the public has rising expectations that disease control officials should get it right the first time.

In some cases, public expectation for disease control is absolute. As an example, consider what a foot-and-mouth disease (FMD) introduction into the United States might be like. A model of an introduction was constructed by M. W. Miller, based on the 1967–68 FMD epidemic in the United Kingdom. The model showed that decisions about appropriate resource allocation and actions would have to be made very quickly, within days—if everything were not done right, within four weeks the epidemic would be uncontrollable. Other studies have indicated that the smallest FMD episode in the United States, say one represented by the discovery of virus on one farm, would cost more than $1 billion. With FMD, the concerned public (livestock farmers and rural people whose employment depends upon livestock industries) has a very high level of expectation that everything would be done right—this public believes that its tax money has paid for standby resources to deal with an episode, no matter what. This public would expect that if necessary the National Guard and the Army would be called out, that all government resources would be used to deal with the problem. There are several human viruses that have the same transmissibility characteristics (reproductive rate, Ro) as FMD virus. Most happen to be those controlled by childhood vaccination programs, but other human viruses could emerge with transmissibility characteristics like FMD viruses, so the need for systems for flexible allocation and delivery of disease control resources is an important issue. In this regard, the public will have to understand better that resources to deal with any eventuality will cost much more than present allocations to national response agencies, and that additional funds will also have to be lodged in international agencies like the World Health Organization (WHO) if we are ever to be able to deliver appropriate global response.

As one goes further and further along the "discovery-to-control continuum," intervention gets tougher and tougher. Frustration often occurs at intermediate points along the continuum as administrators and politicians drag their feet in regard to resource allocation ("No one ever says 'no'—it's just that nothing happens."). This frustration, in turn, drives scientists back to their laboratories, to the world of research, to the front end of the continuum. Younger scientists, particularly, develop an abhorrence for the harsh political world of risk management, even though this is the arena wherein their discoveries must prove themselves.

More and more expensive, specialized expertise and resources come into play in the final phases of the continuum:

1. Public health systems (including rapid case reporting systems, ongoing surveillance systems, vital records and disease registers, additional staffing and staff support, logistical support such as facilities, equipment, supplies and transport, legislation and regulation development, and senior management, administration, and leadership)
2. Special clinical systems (including isolation of cases by quarantine [usually requiring legal authorization and enforcement] and/or strict barrier nursing, patient care and management, and improvement in the general health of the population at risk)
3. Specialist and public infrastructure systems (including sanitation and sewerage, safe food and water supplies, environmental control, and reservoir host and vector control)

One last comment on the continuum: in recent years, it has seemed inevitable that research has been stopped when the goal of control of a given disease has come into sight. For example, measles research, globally, virtually stopped after the attenuated live-virus vaccine came into use 40 years ago, and arbovirus research, globally, is today minuscule relative to its scope and scale 20 years ago. The over-riding issue here is global funding—it has dried up in regard to the need to continue research to deal with the new tricks of microorganisms and viruses.

Applying the "discovery-to-control continuum" to bioterrorism and national and international security

The "discovery-to-control continuum," as described, has been meant to pertain to natural threats, threats stemming from natural changes in microbial or viral agents, *per* *se*, or from innocent ecologic, environmental, behavioral, societal, or commercial perturbations leading to disease emergence. Nevertheless, since a framework is needed to discuss "unnatural threats," and since it is a practical necessity to integrate all elements of our national capacity to identify, characterize, quantify, and respond to microbial and viral threats, it may be of interest to test the appropriateness of the continuum in regard to the threat of bioterrorism.

First, the elements of the continuum would likely be the same as in a natural threat episode regarding discovery, the recognition of a disease in a setting suspicious of bioterroristic activity. Initially, responders and local clinicians, pathologists and public health officials would most likely be the first to recognize an unusual disease episode. At first, it is unlikely that bioterrorism would be suspected—a terrorist-caused infectious disease episode would not present the unique time/place characteristics as other kinds of terroristic actions. It seems likely that the usual civilian field-based epidemiologic investigation and laboratory-based etiologic investigation would follow, again because it is unlikely that bioterrorism would be suspected. Then, as the nature of the microorganism or virus was discovered, either because of unique clinical characteristics or more likely because of work in the primary laboratory or the state or national reference laboratory system, the agencies concerned with national and international security would take over. At this point, quite a different continuum would be set into motion, but with the same purpose, that is disease control and prevention (response against the terrorist agency, once identified, is not part of the continuum in this model).

Given the character of infectious agents, including all those that have ever been considered as bioterrorism threats, a major focus of national security and law enforcement agencies would have to be microbial or viral source elimination, perimeter isolation, confinement and quarantine of exposed people and animals, area decontamination, and other area-based activities (although with human movement, with fomite transport and with vector-borne agents area confinement would not be simple). Seemingly, many of the professional activities called for are quite specialized and not readily available in any appropriate scale in the public health agencies. The question is whether they are available from the military or other national security agencies. This question must be begged in regard to, for example, supplies, equipment, on site facilities, transport and other logistics, staffing and staffing support, management and administration systems, trusted knowledgeable leadership, legislative and regulatory authority and law enforcement, special surveillance resources, case reporting, vital records, disease register resources, training and professional clinical outreach resources, public education resources, specialized patient care resources, and technology transfer.

The metaphor for envisioning a national or even international bioterrorism response system is the national response system for dealing with a terrorist bomb or an earthquake or hurricane. Yet, responding to a bioterrorism episode is different enough, especially in regard to the need for specialized microbiological and virological expertise, equipment, supplies and logistics, that it would seem necessary to play out separate "war games" to help understand the question of preparedness. Since the answer to the question of preparedness may in part be classified, it is not clear how much further this matter may be pursued in the open literature, or through the usual civilian channels discussed above. How can the concerned public be assured that national security and law enforcement agencies are "up-to-speed"? How can the concerned public be assured that there is appropriate interagency cooperation, communication, and collaboration in regard to dealing with bioterrorism threats as there is in dealing with natural emerging disease threats? How can the concerned public be assured that there is an appropriate interagency administrative and management system in place, with appropriate leadership identified, to deal with bioterrorism threats? Three examples point to present difficulties in answering these questions:

1. <u>Unclassified descriptions of "war games" involving exotic pathogens have not been encouraging in regard to any sense of preparedness.</u> In 1989, Col. Llewellyn Letgers, U.S. Army, organized an exotic disease response exercise at the annual meeting of the American Society of Tropical Medicine and Hygiene. Knowledgeable "actors" representing the leadership of all involved federal agencies dealt with a mysterious hemorrhagic fever outbreak, following a realistic script and timeline. In the end, it seemed quite clear that the United States has no interagency "team" or ready-to-go framework for dealing with a large exotic disease outbreak. (Garrett 1990)

2. <u>Interagency planning to deal with natural emerging disease episodes has not been followed by appropriate federal funding.</u> In 1995, the report of the NSTC Committee on International Science, Engineering, and Technology (CISET), entitled "Global Microbial threats in the 1990s" was published. It represented the cooperative input of 17 federal agencies and called for improved global surveillance, improved global alert/response capability, increased targeted research and training, and an enhanced national collaboration and communication system. The report of the committee included the statement: ". . . an effective global disease surveillance and response network will enable the United States to respond quickly and effectively in the event of terrorist incidents involving biological or chemical agents. The experience gained in controlling naturally occurring microbes will enhance our ability to cope with a biological warfare agent, should the need arise. The release of nerve gas in the Tokyo subway system in March 1995 has underscored our need to be well prepared to counteract deliberate attempts to undermine human health."(NSTC/CISET 1995) At the time of this writing, late in 1996, there was little evidence that the CISET proposal would be appropriately funded.

3. <u>Attempts to provide centralized national leadership to deal with bioterrorism and aspects of chemical, biological and nuclear threats have been stymied by turf and primacy issues among federal national security agencies.</u> In 1996, the Nunn, Lugar, et al., act "Defense Against Weapons of Mass Destruction" (U.S. Senate Bill 1745, title XIII), outlined in excellent fashion the nature of the non-military target risks faced by the United States from rogue governments and terrorist movements. The bill noted post–Cold War changes that accentuate the risks (small, difficult to detect weapons; simple transport systems including commercial cargo and FedEx) and noted the inadequacy of our present state of preparation, training, coordination (local, state, federal, interagency) and

sharing of expertise and capabilities. The bill passed, with funding authorized but not appropriated, but only after the role of a national coordinator was minimized. Public discussion suggested that it was national security and law enforcement agencies that preferred a less integrated organization.

Notwithstanding these difficulties in developing and funding a federal interagency action arm to deal with emerging disease risks and similar risks posed by bioterrorism, there has been much recent progress in advancing surveillance and investigative programs: the National Center for Infectious Diseases (NCID) at the CDC has received funding for the first elements of a national emerging infectious disease network. Some progress is also being made in advancing an international network under the auspices of the WHO. The final element, the keystone of the whole edifice, is the research base for all of these programs—much research expertise in emerging infectious diseases is lodged at the CDC and much expertise in biological warfare defense is lodged at the U.S. Army's Research Institute for Infectious Diseases (USAMRIID). However, the largest part of the pertinent research base is lodged in academic institutions and biomedical research institutes throughout the country. The same is the case in other developed countries. The National Institutes of Health, through its extramural programs, has a long tradition in tying together the many disparate parts of the biomedical research community of the country, and recently much progress has been made in tying together academia and the NCID/CDC. Where is the basic research base to support bioterrorism risk management activities in the national security and law enforcement agencies other than the U.S. Army? Should these agencies rely on interagency cooperation or ad hoc consultants? How is the concerned public to know whether the overall system to deal with bioterrorism is working? Surely, recognizing the value of the flow of information and expertise between surveillance, diagnostics, related biomedical research, and other phases of the "discovery-to-control continuum" requires a tightly integrated national system, with clear authority and leadership, and with financial resources so as to be able to deal very quickly with any bioterrorism threat.

Conclusions

In an editorial on May 12, 1995, the *New York Times* asked, "So, who will be the world's public health doctor?" It seems that many institutions, including the CDC, the NSTC/CISET and the WHO, now have the answer to this question. The answer is in the form of proposals and funding requests to expand (1) a global disease surveillance system, (2) a global diagnostics system, (3) a global integral research base, (4) a global communications system, (5) a global technology transfer system, (6) a global emergency response system, (7) a global training program, and (8) a global stable-funding base. In some cases, these proposals have been condensed into a mantra—"surveillance, diagnostics, infrastructure"—but this over-simplification does not seem helpful. In any case, little new funding has been committed to date and, in my view, more, much more, public explanation of the importance of the "global emerging infectious disease network" is needed if this is to change. In some cases, it seems that senior political staff officers are saying, "Those fellows in the citadel just want more money to do their thing, to support their personal adventures," or "If things are so bad, then how did those fellows crack the hantavirus pulmonary syndrome episode in the United States in a week and how did they resolve the Ebola hemorrhagic fever episode in Kikwit in a month?"

It seems clear that the bottom line issue is funding and our failure to communicate the need for funding. Today, many activities involving disease control are at risk because of inadequate funding—this is leading to failed infrastructure, failed intellectual base, failed training of the next generation of specialists, etc. In the case of the emerging infectious diseases, *per se*, failure occurs quickly when research is stopped. For example, tropical infectious disease research, nationally and globally, is today minuscule relative to its scope and scale 20 years ago. In some cases, it is not even clear who might do the focused, applied research that must underpin advances in tropical disease prevention and control. In present circumstances, where the survival of institutions is at stake, turf battles are exacerbated and competition rather than cooperation between academic institutions and government agencies ensues. This happens in contradiction to public expectations: There are clear data that the concerned public wants more disease control and intervention actions and the medical research needed to drive such actions, and there are clear data that the concerned public is willing to pay for this. Our most senior political leaders, however, have not understood or responded to this rising public expectation. How can this kind of indifference be overcome? I am not sure, but here are three ideas:

1. Develop a greatly expanded communications system, reaching up, down and across, bridging with comprehensive information the gap between (a) the rising public expectations for more disease prevention and control action and the biomedical research that must underpin it, and (b) the seeming satisfaction of political leaders with the present state of affairs.
2. Integrate the "global emerging infectious disease network" with networks focused on threats posed by livestock animal diseases, crop plant diseases, and bioterrorism and diseases pertaining to national and international security. The public should see such an overall network as having a high "benefit: cost" ratio, solving several high-priority problems in a most efficient way.
3. Integrate the national emerging infectious disease "needs list" more clearly with a comprehensive set of public health control strategies—including proven interventive approaches such as safe food and water systems, sewerage systems, vector control systems, vaccine usage systems, and primary medical care systems. The public would then see this "holistically," as an overarching national need, not just another rationale for gaining more funding for those in the citadel.

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Nuclear materials

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Major progress has been made in advancing from studies to actions in dealing with nuclear materials. At the same time, the continuously changing nuclear situation provides an impetus for review of nuclear materials stewardship and facilities. As we solve yesterday's problems, new ones emerge. Meeting this challenge requires a technically sound, integrated strategic approach to nuclear materials stewardship. Crosscutting and accessible technical information, analytic tools, and programmatic insights are needed for optimum coordination of nuclear materials stewardship activities.

As great as the problems of nuclear materials management are for the United States, there are both larger and less well-bounded problems internationally. These include not only military nuclear material in the former Soviet Union, but also civilian nuclear material worldwide, and the proliferation risks associated with both. In the former Soviet Union the problems are exacerbated by significant political and economic disruptions. The U.S. practice has been, when confronted with a foreign proliferation or radiological emergency, to take action as needed on a case-by-case basis. In some cases, this has resulted in bringing nuclear material into the United States for disposition. This creates the need for an integrated U.S. approach to nuclear materials stewardship that acknowledges the impact on the United States of these international nuclear materials, and that plans both facilities and processes to accommodate them.

An integrated national approach to nuclear materials stewardship could enhance the ability to (1) conduct nuclear operations more efficiently and (2) provide policy guidance in nuclear material–related matters to meet U.S. national security, energy, and environmental objectives that sometimes conflict. By providing strategic tools that look at the entire system impact, this approach will help make more cost-effective, transparent, and compelling decisions. The Department of Energy (DOE) could take the lead in bringing this new approach into practice.

Historical perspective

About a decade ago, the world order was dominated by two great superpowers with large nuclear arsenals. Only three additional countries had overt nuclear weapons capability. Nuclear power was largely confined to the United States, Western Europe, the Soviet bloc, and Japan. It was managed under the International Atomic Energy Agency's nonproliferation regime. Driven by concerns regarding safety beginning with the 1979 Three Mile Island incident and continuing with the 1986 Chernobyl disaster, nuclear power economics in the United States became increasingly unfavorable. Construction delays increased capital costs, and increasingly stringent safety regulations drove up operations and maintenance costs. However, nuclear power plants were under construction in the United States, and despite the lack of new orders, the return of the nuclear option appeared possible. Passage of legislation governing high-level waste (in

1982 and 1987) and low-level waste (in 1980 and 1985) was perceived to have set the nation on a course toward closure of the nuclear fuel cycle, albeit with direct disposal of spent fuel.

At present, the end of the Cold War has fundamentally altered U.S. defense activities. Production of nuclear-defense fissile material has ceased, and attention has turned to disposition of excess fissile stocks, stockpile stewardship, stabilization and disposal of materials, decontamination and decommissioning of facilities, and environmental cleanup. Diversion prevention has taken center stage, with concern focused on the large quantities of fissile material in an unstable Russia. The number of threshold nuclear weapons states has increased, along with their aggressiveness in attempting to achieve a nuclear weapons capability. There are no nuclear power plants under order or construction in the United States, due to a current economic climate favoring addition of small gas-turbine stations rather than large base-load plants. Both the high-level and low-level waste disposal programs in the United States appear stalled, with an uncertain future. Licensing reforms are in place that might contain capital costs, and the industry has successfully begun to reduce operations and maintenance costs. Yet for the near future, deregulation of the electric power industry may cause a further decline in the number of nuclear plants despite steady improvements in cost and safety.

The same end-of-the-Cold War pressures in the former Soviet Union are resulting in different potential risks for nuclear materials. In addition to the need to dispose of weapons grade materials from dismantlement, Russia and the Ukraine face issues related to continuing production of plutonium (Pu). Also, Russia has not begun the decommissioning and disposal of its weapons complex; therefore, nuclear materials stewardship issues related to that complex process have not yet been addressed.

Outside of the United States, civilian nuclear reactors are being planned, designed, and built. Whereas U.S. projects of nuclear materials from civilian reactors are stable or declining, elsewhere in the world civilian reactor programs are increasing the amount of nuclear materials requiring stewardship. Because of the variety of reactor designs and varying views of plutonium economics, the possible makeup of these materials cannot be anticipated with any degree of certainty. The DOE Energy Information Administration (1996) projects that spent fuel discharge from nuclear power plants will be approximately 10,200–11,499 metric tons (t) per year between 1996 and 2015. The cumulative discharge worldwide of spent nuclear fuel will grow to about 220,000 t in 2015, of which the U.S. share is 40,000 t.

Meeting the challenge

DOE facilities handle a wide variety of nuclear materials. U.S. nuclear materials are used to fuel civilian power reactors and research reactors both domestically and in other countries, to produce various defense-related nuclear materials, and to power naval vessels. Many other valuable nuclear materials are produced in DOE operations, as are a wide variety of wastes containing radioactive components. As a result, the DOE must deal with an extremely complex and dynamic inventory of resources, facilities, and operations in which nuclear materials are created, used, processed, stored, and disposed. Examples of DOE current and future responsibilities include:

- A growing inventory of commercial nuclear power plant spent fuel, currently in excess of 32,000 metric tons
- More than 2 million cubic meters of DOE radioactive wastes, including high-level, low-level, mixed, transuranic, and huge quantities of other, uncharacterized types of wastes
- Hundreds of radioactively contaminated structures, such as reactors, chemical processing facilities, and laboratories
- About 3.7 billion cubic meters of contaminated soil and groundwater at federal nuclear sites and other locations
- More than 600,000 tons of nuclear production materials accumulated to support the nation's civilian and military nuclear programs, including highly enriched uranium (U) and plutonium (Pu)
- About 17,000 nuclear sources used for medicine, waste management, industry, and research
- Fissile material from the former Soviet Union, and foreign research reactor fuel

Nuclear materials issues span three major areas of interest—national security, energy, and environment—as shown in Figure 22-1. Each area has a distinct constituency among the public and in Congress. All three are vital to a safe, secure, healthy, and prosperous future—hence the need to achieve a balanced, coordinated materials management regimen.

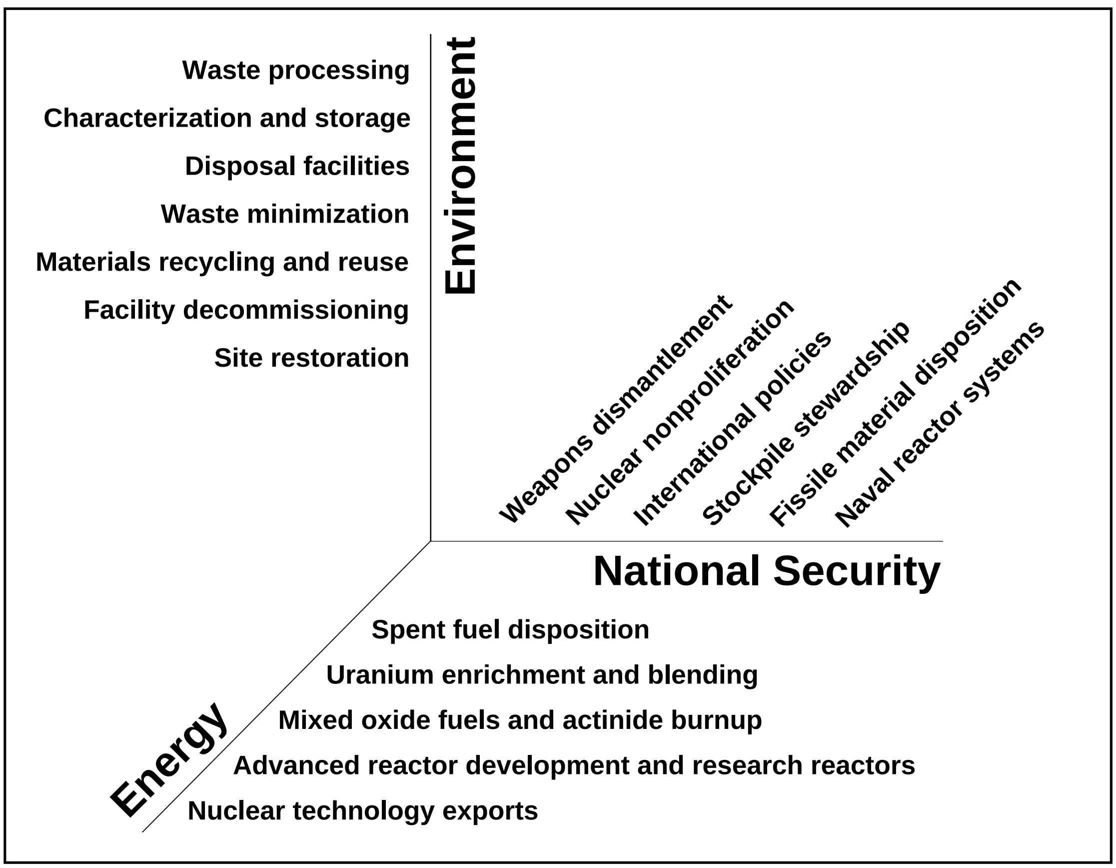

Figure 22-1. Interacting nuclear materials considerations in the areas of energy, environment, and national security.

Each of these missions has complex technical, policy, economic, legal, and political considerations that affect nuclear materials management at both national and international levels. Nuclear operations at DOE facilities have resulted in environmental contamination, forcing programmatic priorities and budget allocations to focus on cleaning up hazards and on modifying continuing operations. In some cases, promises for cleanup have been made that might be difficult (if not impossible) to fulfill, particularly using current technology and projected budgets.

Nuclear materials management is governed by numerous laws, regulations, and regulatory agencies; by DOE's responsibilities to state and other federal agencies; by U.S. cooperation with international organizations; and by U.S. treaty obligations with foreign governments. At least seven major DOE program offices are responsible for various elements of nuclear materials management. Decisions involving individual policies, facilities, or materials are sometimes made without full consideration or knowledge of ripple effects that the decisions trigger.

As we wrestle with the need for new domestic facilities and operations to store, process, transport, and dispose of nuclear materials and nuclear wastes, we are faced with unprecedented technical and nontechnical challenges. At the global level, the dissolution of the Soviet Union has lessened tensions between the United States and its former adversary. As a result, both the United States and Russia are dismantling large numbers of nuclear weapons, producing surpluses of plutonium and enriched uranium. Definitive and technically sound policies and plans for the disposition of these and other materials are urgently needed, both to handle the materials in a safe and environmentally responsible manner and to prevent the proliferation of nuclear weapons and weapon materials.

The U.S. policy of taking foreign nuclear material into U.S. nuclear stewardship has had significant positive effects on world nuclear safety and nonproliferation goals. Examples include weapons-grade material from Kazakstan, highly enriched uranium from Russia, and foreign research reactor spent fuel. The U.S. policy of leadership by example has introduced additional amounts of nuclear material into U.S. nuclear stewardship, for example when the president identified 200 tons of weapons-grade materials as excess to U.S. needs. As the United States develops a robust, comprehensive integrated framework of nuclear materials stewardship, the totality of U.S. environmental and national security interests must be represented. This includes adequate facility capability and policy framework to meet realistic international contingencies and provide policy flexibility for U.S. international leadership.

All of these critical needs must be satisfied as U.S. nuclear hegemony is in decline. Much of the rest of the world is expanding nuclear energy as the United States reduces its role, resulting in less opportunity for the United States to influence their decisions. U.S. commercial nuclear power is declining as a percent of worldwide operating reactors (24.7%) and capacity (28.7%). The United States is now eighteenth out of 30 countries in the world in percent of electrical generation from nuclear reactors (22.5%). The U.S. monopoly on enriched uranium supply has ended, and U.S. nuclear reactor suppliers face intense foreign competition. It seems possible that Sweden will operate its high-level-waste repository before the United States, despite our emphasis on schedule from the start. Virtually all nuclear countries are more advanced in implementing disposition plans for commercial low-level waste than the United States.

Where are we and how did we get there?

In the rush to assign blame for the nuclear materials problems, it is too often forgotten that people made decisions that seemed right in the context of the time. Looking at things in the light of today's knowledge, priorities, and conditions, we see things very differently. For us to deal successfully with many issues, we must look beyond being pro-nuclear or antinuclear to being *about* nuclear. Applying this perspective, let's look at some of today's nuclear materials management issues from the viewpoint of an ideal system that is (1) planned and tested prior to deployment, (2) comprehensive, (3) internally compatible, (4) optimized as a whole, (5) robust, and (6) realistic.

Planned and tested prior to deployment

The essence of systems engineering is to plan and test an entire system prior to deployment. Two conditions prevented this for nuclear materials management in the United States—the conditions under which the nuclear system originated, and the first-of-a-kind nature of the activities.

The system of nuclear materials management in this country was born of necessity during a war of survival. While thousands died daily from international strife, a few gaps in planning did not seem significant. This pressure was relieved by a short post-war pause before nearly four decades of what has been termed a "balance of terror."

Fifty years ago all nuclear activities were pioneering—the first sustained chain reaction at the University of Chicago, the enrichment of U^{235}, the production of plutonium, radiochemical processing, and the Trinity explosion. No systematic cycle through research, development, and pilot plant to production was possible. Plants were under construction before the engineers knew from the scientists what equipment would be installed there.

Beyond these historical factors, many analysts now believe that it is not possible to completely plan a complex new system prior to implementation, and that new systems should be prototyped and significant changes should be expected early and often. Other new technologies have gone through many cycles of change before settling down into a more mature stable phase. From this perspective, significant changes should be expected as a normal part of nuclear materials stewardship. These changes can be managed through information, tools, and insight, and by recognizing adaptability and flexibility as virtues in system approaches.

Comprehensive

Even though the nuclear materials management system may not be fully implemented, it should be comprehensive (in the sense of all-inclusive) with respect to plans and concepts. The most obvious gap is the lack of closure of the nuclear fuel cycle[1]. For commercial power reactors, the fuel cycle has been "closed" several times but reopened by stricter environmental controls or political decisions. These are reasonable responses to changing boundary conditions. On the other hand, it is not reasonable that today, 50 years into the nuclear age, there are still not credible disposal plans for all nuclear waste. Other examples of system incompleteness are the gaps in U.S. nuclear waste classification, the lack of an integrated transportation system, and lack of international considerations in planning.

Lack of credible plans for all waste. The statutory limit of waste loading for Yucca Mountain is 70,000 t of initial heavy metal, which has been allocated by DOE into 63,000 t of commercial reactor spent fuel and 7,000 t of defense waste. However, by the end of the currently planned lifetime of commercial light water reactors, projections are for 84,000 t of spent fuel. About 10,000 t of defense high-level waste and 3000 t of DOE spent fuel are projected. With just these categories totaling nearly 100,000 t, clearly either a second repository will be needed, or the statutory limit at Yucca Mountain raised.

Beyond the statutory-limit issue, there are 256 types of spent fuel alone in the U.S. inventory, and only a few have been analyzed and approved for disposal in the repository. Among other items mentioned (but not planned) for Yucca Mountain are spent naval fuel, plutonium disposition products, depleted uranium, and Greater-than-Class-C low-level waste. The required safety demonstration for these other types could be time-consuming and costly.

Just because a certain waste has a disposition stated in a program plan or environmental impact statement does not mean that the disposition is likely or feasible. For example, there is no certainty that a Yucca Mountain high-level-waste repository will ever open.

Disposal of commercial low-level waste in the United States is stalled by the political process. Only one commercial site is open to most of the country, and the prices have escalated to nearly that of high-level waste on a volumetric basis.

Waste classification gaps. In most nuclear countries, waste is classified by radiation dose level or curie concentration as low-, intermediate-, or high-level. In the United States, low-level waste is defined by curie concentration, and high-level waste is defined by origin. Although the curie concentration of high-level waste is separated from low-level waste implicitly by the current U.S. classification, there are unclear boundaries for other types of waste. There is no clear-cut intermediate classification, although several categories span the gap.

The DOE has defined a category known as TRU waste that contains alpha-emitting radionuclides with an atomic number greater than 92 and half-lives greater than 20 years, at concentrations of transuranic isotopes greater than 100 nanocuries per gram of waste. The Nuclear Regulatory Commission in defining low-level waste established the category known as Greater-than-Class-C, which is defined as having greater than specified limits to radionuclide content measured in Ci/m^3 or nCi/g on a nuclide specific basis. No upper limit is given, and it is only stated that it does not qualify for shallow burial. Because this definition allows the radiation level to be potentially as high as some high-level waste, it is assumed (but not formally required) that Greater-than-Class-C waste will be disposed in a high-level-waste repository. However, from a risk-benefit standpoint this may be unproductive. Likely some Greater-than-Class-C waste should go to a high-level-waste repository, but much should not and the economic penalty is not known.

Another waste classification gap appears for the disposal of plutonium, enriched uranium contaminated with other isotopes, and high fissile content spent fuel. The statutory, regulatory, and programmatic focus of the U.S. high-level-waste repository program is the disposal of high-level defense reprocessing waste and commercial light-water-reactor spent fuel. Yet there are large quantities of plutonium and high fissile content spent fuel that some propose for the repository, largely for nonproliferation reasons. The disposition of contaminated enriched uranium is not even addressed. The repository is not being designed for these materials, which present potential problems in criticality and long-term toxicity.

<u>Lack of an integrated transportation system.</u> In the Swedish nuclear power system, despite having several utilities involved, the fuel cycle was planned as an integrated whole. All power reactors and the spent fuel storage facility are located on the seacoast, so that transportation of fresh and spent fuel is by a specially designed sea transport vessel. The limitations of geography in the United States would not allow all coastal locations, but we have not taken other obvious steps. Not all power reactors are accessible by rail, and not all can accommodate large, cost-effective transport casks.

<u>International considerations in planning.</u> Provisions should be included that allow for the classification of waste from foreign sites, including instances in which the life-history of the materials may not be known. U.S. policy objectives may also be met by encouraging and promoting technology transfer to facilitate foreign nuclear materials stewardship issues. These may be either country specific or regional. In either case, advance planning and long-term resource commitments by the United States are necessary in addition to a robust policy framework and strong technical competencies.

Subsystems compatible

Subsystems should be compatible with each other and the overall system. Although there are many additional components, the three major programs of the DOE nuclear arena were weapons, naval reactors, and civilian reactors. Although U.S. policy from the start has been to have a strong separation between civilian and defense programs, the programs initially operated under parallel but similar policies. That is, all the programs planned to reprocess and recycle the fissionable materials. Waste materials could be handled in a common system. Today we still have a common high-level-waste repository, but the materials from the various programs are dissimilar. To the mix has now been added the possible disposal of excess fissionable materials. It may be necessary to examine the inherited assumption that all high-level waste (including spent fuel) can or should go to the same repository.

Optimized as a whole

Subsystems should not be optimized at the expense of the overall system. For example, for economic reasons, spent naval-reactor fuel is no longer reprocessed. However, spent naval-reactor fuel is highly enriched, and no significant effort has been made to demonstrate that such fuel can meet current repository standards without significant additional conditioning or packaging. By ceasing to reprocess the naval fuel, the fuel subsystem has been economically optimized at the possible expense of the disposal subsystem.

Another example is the excess weapons fissile material. A decision was made to disassemble weapons rapidly and store plutonium prior to disposition, either as parts or some processed form. However, weapons are under very tight controls and accountability, and exist in easily countable form, whereas plutonium becomes more hard to control and account for with each step of processing; therefore more easily a subject for diversion. It has been suggested that the reduction in warheads may have led to an increase in diversion risk.

Robust

The system should be robust enough to survive changing external boundary conditions. Early in the development of the nuclear materials management system, uranium was thought to be a scarce commodity, prices were high, and enrichment was expensive. Therefore, the breeder reactor, which converted abundant U^{238} to plutonium, was thought to be an ideal solution. Similarly, recovery of plutonium from spent light-water-reactor fuel and recycle in MOX (mixed uranium and plutonium oxide) reactors appeared resource-wise and economic. Opposition to these system extensions came almost exclusively from antinuclear activists who were citing weapons proliferation as their main argument. Based on proliferation arguments, a major boundary condition change was made in 1977 when President Carter announced the indefinite deferral of reprocessing in the civilian nuclear sector. Several years later, direct disposal of spent reactor fuel (the once-through cycle) became administrative policy.

Today, uranium is abundant, the price is cheap, and the cost of enrichment has greatly declined. Many regard reprocessing as not cost-effective and spent fuel as a waste rather than a resource. Even highly enriched naval reactor fuel is now in a "once-through" cycle. However, part of the nuclear world continues to treat spent fuel as a resource rather than a waste. France, Germany, Great Britain, Belgium, Russia, and Japan all have their spent fuel reprocessed and either operate, or plan to implement, the MOX fuel cycle.

Politics can affect boundary conditions as strongly as resource availability and economics. Our management of depleted uranium, plutonium, and highly enriched uranium illustrates how nuclear materials management can be an instrument of policy as well as a technical process. Technical optimization needs to be balanced against institutional, economic, and political aspects to reach effective and achievable decisions.

To enhance our nonproliferation objectives, U.S. policy is committed to the once-through fuel cycle, in which there is no reprocessing and the spent fuel is waste. For commercial light water reactors, economics appear to favor the once-through fuel cycle, at least at present and near-future uranium prices. However, the United States has large stocks of depleted uranium, plutonium, and contaminated enriched uranium from reprocessing defense, research, naval, and experimental fuels. These do not readily fit into the planned waste repositories. The enriched material could theoretically be used as fuel, thus gaining some benefit from the already-spent cost of the reprocessing. However, in order to be consistent, the United States is considering as a matter of policy to forego burning these materials in a reactor and attempt direct disposal in order to set a positive example to the rest of the world supportive of nonproliferation. Furthermore, reprocessing future similar spent fuel has been abandoned.[2]

Another example is the lack of spent fuel storage capacity at commercial reactors. Early reactors were designed with limited pool storage capacity for spent fuel because of the regulatory expectation that all spent fuel would be reprocessed. It was even required that the reprocessing waste be solidified within five years. Thus a small pool capacity was a reasonable assumption for designers. Certainly, no one would have planned for life-of-plant storage. All solutions to date (ship to another reactor, ship to an away-from-reactor storage facility such as Morris, rerack the fuel, or move to an onsite, external dry storage) have been ad hoc, with no real national solution. National solutions have been proposed by DOE [monitored retrievable storage facility, multi-purpose (store, transport, dispose) canisters], but not adopted by the country.

Realistic system specifications

As the regulations and policies have evolved, there has been a gradual shift from concern about short-lived radionuclides remaining in high-level waste (and therefore repository performance for a few hundred years), to the long-lived isotopes remaining in spent fuel and repository performance of a million or more years. The degree of protection demanded is neither feasible nor demonstrable. In this case, the unrealistic specifications are imposed from outside the system, as boundary conditions.

Sometimes the system specifications can be technically realistic but unrealistic for nontechnical reasons. This has particularly plagued nuclear materials management. Problems have been approached solely as technical issues, but the resulting technically sound solutions have failed for institutional reasons. Therefore, a successful nuclear materials stewardship system must include nontechnical considerations to be realistic. A good example is the potential high-level-waste repository at Yucca Mountain. Nearly all effort is focused on whether the site is technically acceptable for waste isolation for 10,000 or even a million years, but the extent to which nontechnical issues are integrated into the program is more likely to determine ultimate success than any set of technical data and analyses. Other examples include the low-level-waste site at Ward Valley, which has received a license to operate but is halted by political opposition. The Shoreham nuclear reactor was granted a Nuclear Regulatory Commission license and started low-power operation, but was halted by political considerations.

A possible framework

A national, integrated view would provide significant advantages for managing U.S. nuclear materials. This view can be achieved with information and tools leading to insights that make it possible for DOE, national decision makers, regulators, and commercial providers to take into account all relevant and often competing issues (*e.g.*, technical, legal, regulatory, political, economic, institutional) and systematically identify opportunities, risks, benefits, and costs for various nuclear materials management options.

To achieve such a view, we should begin with a comprehensive, strategic analysis of current locations, quantities, and conditions of nuclear materials nationwide, along with storage, processing, and disposal plans. Specific areas to be examined include the following:

Material regulations and classifications. Examine regulations, classifications, and standards and their impact on nuclear materials management, and develop alternatives for a more consistent, more efficient approach.

Material stocks and flows. Understand what nuclear materials we have, where they are, and where they are going; define gaps and disconnects; and identify technical options, alternatives, and research needs for processing and disposition paths.

Data identification and analysis. Assemble nuclear materials management information and analyze its implications for effective program management and operations, and provide a basis for identifying and resolving policy issues. This information will derive from program plans, records of decision, environmental impact statements, directives and orders, standards and regulations, policies, treaties, inventories, and other such sources.

Information management system. Develop a prototype information management system to help users obtain and understand relevant nuclear materials management information, constraints, and related data, and to provide a basis to optimize management decisions.

Objectives hierarchy. Prepare a hierarchy of objectives that distinguishes high-order goals such as "minimize global nuclear weapons capability," from objectives such as "prevent proliferation of uncontrolled plutonium," from proposed solutions such as "try to prevent all reprocessing." Use this hierarchy and influence diagrams to identify unintended effects of actions taken to satisfy one objective on other objectives.

The payoff

With the technical foundation thus created, we can move toward the development and implementation of a more unified and effective national program for managing the use, storage, processing, and disposal of nuclear materials. Specific benefits include:

- Improved decision making and policy implementation (*i.e.*, greater consistency and more defensible rationale), improved risk management, and lower costs for the management of nuclear materials
- Improved integration and coordination of nuclear material-related activities nation- and agencywide and improved safety, security, and efficiency of nuclear operations
- An information management system, information analysis tools, and technical and nontechnical insights for decision makers, along with a dynamic system to obtain meaningful stakeholder involvement
- Identification of research and development that really makes a difference in providing meaningful nuclear management options, and that provides a basis for use and benefit from advances in the state of the art
- Improved understanding of ramifications and implications of existing and proposed nuclear-material-related policies and regulations

- A strengthening of U.S. security, energy, environmental, and waste-management policies

No single system can capture all the subtleties and complexities of the real world, let alone the many disparate yet legitimate views held among the nuclear community and the nation. But by assembling an agreed-upon, common set of strategic *information*, and a set of *tools* that can be used by all of us, the resulting *insights* from analysis—combined with open and effective communication among us—should result in better understanding, both of the implications of various decisions and the factors that often lead us to differing solutions even when we share common objectives.

Endnotes

1. Closure is here used in the sense of completeness, which would include disposal of spent fuel, not in the sense of implementing a MOX or breeder fuel cycle.
2. It is interesting that where there is a technical imperative, Purex processing continues in the United States. For example, returned foreign research reactor fuel that is aluminum-clad is being processed for safety reasons—it cannot be safely stored until disposal.

Appendices: Reference documents

Meeting the Challenge of Global Threats National Security Science and Technology Strategy 1996

The decisions we make today regarding military force structures typically influence our ability to respond to threats 20 to 30 years in the future. Similarly, our current decisions regarding the environment and natural resources will affect the magnitude of their security risks over at least a comparable period of time. The measure of our difficulties in the future will be settled by the steps we take in the present.

...Rapid population growth in the developing world and unsustainable consumption patterns in industrialized nations are the root of both present and potentially even greater forms of environmental degradation and resource depletion. A conservative estimate of the globe's population projects 8.5 billion people on the planet by the year 2025. Even when making the most generous allowances for advances in science and technology, one cannot help but conclude that population growth and environmental pressures will feed into immense social unrest and make the world substantially more vulnerable to serious international frictions.

A National Security Strategy of Engagement and Enlargement, 1995

The Problem

The President's 1995 National Security Strategy of Engagement and Enlargement recognizes that a broad class of global threats evident in the post-Cold War world affect our nation's security. **The United States is not isolated from the effects of disease, disasters, or misery elsewhere in the world. In the modern world, diseases readily cross borders, and environmental degradation can have global consequences that threaten the populations of all nations.** Great human suffering due to natural disasters or to other environmental, economic, or social and political factors may lead not only to large numbers of refugees crossing international borders but also to instability that increases the likelihood of ethnic and regional civil conflict. Understood in these terms, the security of the United States therefore requires engagement with the developing world and with countries in transition to democracy, to take steps to prevent deadly conflict, to encourage economic development that can be sustained for growing populations, and to respond to threats to the environment and human health.

Outbreaks of new or reemerging infectious diseases may endanger the health of U.S. citizens even if the root causes of the problem lie in distant parts of the world. The tragedy of HIV/AIDS has already made this clear. Diseases affecting humans, plants, and animals are spreading rapidly as a result of trade and travel and, especially when combined with malnutrition, threaten public health and productivity on a broad scale. The rapidly growing human population, widespread pollution, and the deterioration of other environmental factors that contribute to the maintenance of good health, as well as the lack of dependable supplies of clean drinking water for fully a fifth of the world's people, contribute to the acceleration and spread of such diseases.

Natural disasters, the burden of which falls disproportionately on the poor, pose an especially dramatic threat to sustainable development. The costs of natural disasters are high and have been escalating. For example, domestic natural disasters (ranging from hurricanes, earthquakes, and floods to wildfires and ice storms) now cost the United States more than $1 billion each week. Internationally, the impacts can be greater still. In addition to causing widespread human tragedy and loss of life, for the poorest nations of the world a single natural disaster can reduce the gross national product for that year by as much as 25 percent. Losses of this magnitude represent enormous setbacks to a nation's or region's economic and human development. And in a number of regions, these events occur frequently.

Whereas natural disasters threaten human life and sustainable development in a catastrophic manner, global threats such as climate change, ozone depletion, and ocean pollution may take years or even decades to become apparent and build toward crisis. Yet each of these poses challenges to the health and long-term well-being of both U.S. citizens and people throughout the world.

The loss of biodiversity is an especially urgent threat, the consequences of which are irreversible. The permanent loss of species means we will no longer have these organisms as sources of medicines, oils, fibers, food, chemicals, and other commodities of importance to both industrial and developing societies.

The explosive growth of the world's population is of primary importance and exacerbates many of the dilemmas already discussed. Recent history has shown that, in some developing countries, even the most impressive gains in total economic output can be offset by rapid population growth. Population pressures already contribute to violent disorder and mass dislocations in poor societies. Internally displaced persons-who might become refugees-pose a long-term threat to the integrity of their own and other nations as well as to global stability.

As the world's population grows to exceed 8 billion people by 2025, most of this increase will occur in the cities of developing countries. Worldwide, urban population is expected to increase from 1 billion people in 1985 to 4 billion in 2025. Increases in income, greater urbanization (which leads to a shift in diet from roots, tubers, and lower quality grains to higher quality cereals, livestock, and vegetables), and overall population growth could mean that the demand for food in 2025 will be more than double that of current levels of production.

Individually or collectively, threats such as these can increase the likelihood of destabilization of countries in the developing world. Regional or civil conflicts, hastened or exacerbated by environmental stress, could involve the United States in costly and hazardous military interventions, peacekeeping, or humanitarian operations. As is the case in Haiti, severe environmental degradation and resource depletion may make economic recovery much more difficult, thereby prolonging dependence on aid and impeding a nation's recovery from social or political chaos and progress toward democracy and prosperity.

The Challenge to Science and Technology

Research in the natural and social sciences helps us to understand the origins, characteristics, and consequences of global problems. Finding solutions to these problems, and elucidating the complex chains of cause and effect through which they may be linked, requires a coordinated effort by natural and social scientists, engineers, and policy makers. U.S leadership in science and technology is therefore an important element of our national security.

In some cases, research and monitoring programs offer the only substantial warning to government officials and to the public of an emerging problem. For example, through remote sensing, we can have warning of famine and continue to accumulate a record of the state and evolution of the basic components of our biosphere. Such observations and measurements, coupled with the development of predictive models, are necessary tools for policy making in the post-Cold War security environment.

Transforming scientific breakthroughs into new technologies can have a profound impact on development. Wise stewardship of these technologies is essential. One challenge is to use technology in such a way that it achieves advances in productivity without compromising long-term natural resource viability. For example, technology helped bring about the Green Revolution, which resulted in increased agricultural productivity worldwide. But at the same time, poorly designed irrigation systems led to soil degradation in some areas. In the decades ahead, technology will be required to feed and provide energy for a growing world population while minimizing impact on the integrity of soil, water, air, forests, and other natural resources. In addition, insights from the social sciences can provide the basis for redesigning research and resource management institutions to achieve the efficient use of resources with minimal disruption to the environment. A major parallel challenge to science and technology will be to make contraception more affordable and effective.

Policy Response

The Administration's strategy for meeting the challenges described above rests on three pillars: preventive diplomacy, promoting sustainable development, and responding to global threats. Preventive diplomacy endeavors to resolve problems, reduce tensions, and defuse conflicts before they become crises. The promotion of sustainable development seeks to ensure that development occurs in a manner that can be maintained for the long term, thereby avoiding environmental, resource, or other degradation that fosters poverty and instability. Finally, there is a class of global threats that may take years or decades to become apparent or to build toward crisis but which may directly threaten the well-being of U.S. citizens as well as people around the globe. Responding to these threats will require decisive domestic action as well as international cooperation.

Preventive Diplomacy

The Administration emphasizes support for democracy, sustainable development, traditional diplomacy, and military strength to prevent conflicts from escalating into violence and to contain conflicts that do occur. This strategy defines the practice of preventive diplomacy. When combined with timely early warning systems, and a commitment to use the warning information, preventive diplomacy is a wise investment in national security, offering the prospect of resolving problems with the least human and material cost. The tools of social science are required to identify the most significant factors involved in producing conflicts, and information technologies are needed to detect changes in these factors and to provide early warning. Because this strategy is based on prevention, its successes will often have to be measured in terms of undesirable events that do not happen.

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Promoting Sustainable Development

As part of its prevention strategy, the Administration is vigorously promoting sustain-

Science and Technology for the Prevention of Civil Conflict

The Administration is seeking greater understanding of the role of factors such as endemic poverty, environmental degradation, food scarcity, demographic tensions, and communicable disease in leading to conflict, in order to better design policies of prevention and mitigation. The costs of prevention are most often outweighed by the costs of military intervention once violence has erupted.

The President has asked the President's Committee of Advisors on Science and Technology (PCAST) to examine the interaction between the outbreak of conflict and physical and societal stresses. PCAST will also assess the role that international cooperation in science and technology can play in alleviating these stress factors, thereby contributing to sustainable development and economic and political stability. PCAST will also examine cases of successful and unsuccessful interventions by intergovernmental organizations, international financial institutions, other governments, and non-governmental organizations able development, both at home and abroad. Sustainable development requires that the economies of the world, including our own, try to meet contemporary needs without compromising the resources available to future generations.

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Internationally, the Administration's foreign assistance program focuses on four key elements of sustainable development: broad-based economic growth; the environment; population, health, and nutrition; and democracy and governance. We will continue to advocate environmentally sound private investment and responsible approaches by international lenders. At our urging, the multilateral development banks are now placing increased emphasis upon sustainable development in their funding decisions, to include a commitment to perform environmental assessments on projects for both internal and public scrutiny. In particular, the Global Environmental Facility (GEF), established in 1994, will provide a source of financial assistance to the developing world for climate change, biodiversity, and oceans initiatives.

Population Stabilization

Very early, multiple, closely spaced pregnancies drastically increase the health risks to women and their children, limit opportunities for women, and diminish the ability of families to invest in their children's education and health.

The Administration is leading a renewed global effort to address population problems and promote international consensus for stabilizing world population growth. The United States supports further research to improve existing methods of contraception and to provide a better variety of methods appropriate to different phases of couples' reproductive lives. In addition, the Administration's comprehensive approach stresses family planning and reproductive health care, maternal and child health, education, and improving the status of women. The International Conference on Population Development, held in September 1994 in Cairo, endorsed these approaches as important strategies in achieving global population goals.

In the past, research and development in the field of contraception has emphasized methods with high inherent contraceptive efficacy and safety. Both in the United States and abroad, the increasing need to simultaneously address prevention of sexually transmitted diseases, along with prevention of unintended pregnancies, calls for a shift in emphasis. For this reason, the Administration is now giving highest priority in research and development to products or methods that meet these needs. In addition, the

Defining Sustainable Development

The most commonly used definition of the term “sustainable development” is one that originated with the 1987 report, Our Common Future, by the World Commission on Environment and Development (known as the Bruntland Commission). By that formulation, sustainable development is “development that meets the needs of the present without compromising the ability of future generations to meet their own needs.’

Since the release of the Bruntland Commission report, the phrase has been broadened and modified. The term “sustainable” has gained usage because of increasing concern over exploitation of natural resources and economic development at the expense of environmental quality. Although disagreement exists as to the precise meaning of the term beyond respect for the quality of life of future generations, most definitions refer to the viability of natural resources and ecosystems over time and to the maintenance of human living standards and economic growth. The popularity of the term stems from the melding of the dual objectives of environmental protection and economic growth. A sustainable agricultural system, for example, can be defined as one that can indefinitely meet the demands for food and fiber at socially acceptable economic costs and environmental impacts.

Administration seeks further research specific to the needs of particular countries or regions on the acceptability and use-efficacy of present and future methods.

Food Security

The enhancement of international food security plays an important role in achieving U.S. foreign policy objectives. Chronic hunger can set off a cycle of instability, migration, and, in the worst case, war.

Science and technology have valuable contributions to make by increasing agricultural productivity; sustaining the natural resource base on which productivity depends; adapting crops to changing environmental conditions; furthering good nutrition through the development of better food crops; and improving food preservation, storage, and distribution. This science-based approach will not only enhance food security, it will also foster more sustainable management of natural resources.

With the global population forecast to increase at nearly 90 million people per year, there is no acceptable alternative to increasing productivity of agricultural and other land- and water-use systems. Scientific research is key to increasing yields of land-use systems; past gains stemming from area expansion, and even fertilizer use in some areas of Asia, can no longer be continued. The scientific intensification of agriculture must continue in favored areas, but research applications must also target more marginal areas, many of which are those most threatened by nonsustainable practices and environmental degradation. For example, better management of agricultural chemical use in developing countries can lead to higher yields and less crop loss while limiting the risks to the environment and the health of farm workers. Integrated pest management, conservation tillage, and integrated nutrient management when adapted to resource conditions through research are likely to offer useful technological alternatives.

As a starting point, the United States recognizes the need for a comprehensive program to acquire, document, and conserve genetic resources of economic plants and animals. Germplasm conservation is integral to sustainable agricultural productivity. To this end, the United States conducts a domestic agro-biodiversity conservation program and provides support to important multilateral initiatives.

In some areas, where crop production activities may remain marginally economic, food security will be enhanced through the development and application of science-based, resource-efficient production of livestock, fuel, fiber, or forest products. In this light, enhanced research emphasis is being placed on developing agro-forestry and other systems that provide livelihoods to rural families while protecting the natural resource base. Moreover, post-harvest processing, prevention of losses, and many other income-generating activities can contribute to food security. U.S. programs therefore also include research to reduce post-harvest losses and to develop further applications of agro-industrial crops. U.S. assets are also engaged in remote-sensing endeavors that forewarn of impending famine.

Natural Resource Stewardship

The Administration is acting to ensure the sustainable management of U.S. forests by the year 2000. In addition, U.S. bilateral forest assistance programs are being expanded, and the United States is promoting sustainable management of temperate and tropical forests. The sustainable use of forests is essential to ensuring that these resources will continue to be available to fuel development through the future.

In the wake of the 1992 United Nations Conference on Environment and Development, the United States has sought to reduce land-based sources of marine pollution, to maintain populations of marine species at healthy and productive levels, and to protect endangered marine mammals.

The Administration also places high priority on protecting the ocean and coastal environment and conserving living marine resources, reflecting the important national security, environmental, and economic interests at stake regarding ocean resources. The United States has five principal objectives in this area: (1) becoming a party to the 1982 U.N. Convention on the Law of the Sea, as modified in 1994; (2) ensuring sustainable management of ocean fisheries; (3) supporting integrated coastal resource management and reducing marine and coastal pollution; (4) promoting the conservation of marine biodiversity, including whales and other protected species; and (5) conducting scientific research and ocean monitoring both to support these objectives and to more fully understand oceanic and atmospheric processes of global importance.

Post-Conflict Landmine Clearance

Landmine clearance is an important step toward resumption of economic activity and stabilization following war or civil conflict, and thereby a means of reducing the likelihood of future conflict. Frequently, it is also a prerequisite for the repatriation of refugees. Thus, it is genuinely a development issue.

Humanitarian mine clearance is not the same as clearing mines for military purposes-technologies for breaching are often not appropriate for clearing large settlement areas. However, technological solutions can be improved through communication and cooperation between applicable military technologies and humanitarian mine clearance communities. In the long run, clearance capacity must be built through development of indigenous capabilities that are sensitive to local priorities, policies, socioeconomic factors, and that can continue for the long time required.

The Administration has identified a number of priorities in this area:

- The effectiveness of current capabilities for humanitarian mine clearance needs to be improved dramatically. The U.N. has set a goal of improving it on the order of 50 times the current rate. (According to the UN, only 84,000 mines were cleared in 1993, as compared with 2-3 million new mines laid.) The current costs of approximately $300 per mine cleared must also be cut dramatically.

- Improved technology is needed for locating and discriminating mines (especially from non-mine metal fragments).

- The humanitarian community must develop more specific, systematic technical requirements for the technology it needs-both for incremental improvements to existing technologies and for R&D priorities in hopes of making significant improvements in the future.

- Greater national and international cooperation and coordination of efforts are also needed, including increased public awareness and support, much improved cooperation among military, humanitarian, and economic development agencies in donor and recipient countries, and improved organization and sharing of information.

Mine clearance is a subset of the broader issue of the clearance of unexploded ordnance (UXO), which presents a greater technological problem in detection, characterization, and removal. Whereas land mines are located near the surface, UXO may be buried down to 30 feet. UXO may also have much greater explosive charges. Investment in UXO clearance technology is needed both for the U.S. armed forces and for international economic development.

An understanding of the changing ocean and coastal environment is essential in order to manage ocean resources in a sustainable manner. This Administration places a priority on ocean monitoring and supports appropriate research on fisheries and marine biodiversity, as well as on the marine physical system and ocean-atmosphere relationships important to understanding climate change. The United States will continue to cooperate with other countries and international bodies in support of the Global Ocean Observing System. We will continue to vigorously promote the consistent and equitable implementation by nations of the provisions of the U.N. Law of the Sea Convention on marine scientific research to ensure maximum access to oceanographic data vital to managing ocean resources, as well as for understanding global change. And we will continue to push for international acceptance of the principle of full and open access to oceanographic and meteorological data. This increased emphasis on oceanographic research and monitoring will directly benefit global maritime operation—both civil and military.

Natural Disaster Mitigation

To be sustainable, a society must be resilient to natural hazards. Natural hazards, ranging from earthquakes to pestilence, are inevitable. By contrast, natural disaster—defined as long-lasting disruption of entire communities exceeding the communities' ability to recover unaided—are as much a product of societal behavior and practice as of nature. Natural disasters can and should be mitigated.

The United States is a world leader in developing and implementing technologies for both monitoring natural hazards and mitigating natural disasters. The United States is in the final stages of major improvements in weather forecasting and is working to improve the dissemination of this information. In keeping with its strategy of prevention, the United States provides technical assistance and equipment to other countries to help them predict and assess changes in the natural environment and minimize the loss of lives and property due to natural disasters.

Multi-laterally, the United States is participating in a U.N. initiative intended to ensure that by the year 2000 all countries will have incorporated into their plans for achieving sustainable development comprehensive national assessments of risks posed by natural hazards and mitigation plans for these risks at the national and local levels. Countries will also have incorporated into their plans ready access to global, regional, national, and local warning systems.

Promotion of Knowledge

The preceding discussion makes clear the central role that the dissemination of knowledge and expertise plays in any sustainable development strategy. An effective way to promote sustainable practices globally is through partnerships in teaching and research among developed and developing countries. **A global community of scholars, united by a shared understanding of scientific methodology and responsibility, and linked via modern telecommunication networks, will be a positive force for promoting stability, democracy, and economic development.** This is one reason why the Clinton

Administration has made the development of national and global information infrastructures national priorities.

To promote scientific knowledge abroad, the United States enters into cooperative science and technology agreements with countries around the world. These agreements provide the protocols for cooperative research by government-sponsored scientists and engineers. The United States maintains these agreements, and the intellectual property rights protection contained within them, both for geopolitical reasons and because U.S. scientific and technological leadership can be strengthened through international cooperation. Some of today's most difficult challenges cannot be solved by the United States (or any country) acting alone. During a time of severe budgetary constraints, some projects are too costly for any one nation. Sometimes the work must be done in situ; for example, assessing and preserving biodiversity or monitoring disease outbreaks. Other issues naturally invite collaboration because of unique foreign expertise or facilities. Cooperation builds bridges among nations, sometimes even when no other avenues are available.

The Administration fosters international collaborative research by universities, government, and private sector laboratories with counterparts in developing countries and will also build on the opportunities in existing multilateral efforts. Of particular note are the international agricultural research centers sponsored by the Consultative Group on International Agricultural Research (CGIAR). These centers, which are funded largely by the United States and other OECD donors, link closely to research institutions here and in other developed countries. They represent a key means of developing and delivering food-security enhancing, public-goods technologies to developing countries. With a large contingent of U.S. and U.S.-trained scientists, they represent an excellent means of linking to domestic research.

There are an estimated 1 billion illiterate people in the world. High levels of illiteracy undermine sustainable development goals. Clearly, scientific and technical literacy is required as well. Technology transfer and the development of locally appropriate solutions cannot take place if countries with nearly 80 percent of the world's population (and over 90 percent of population growth) continue to have only 6 percent of the world's scientists. Training students from the less developed sectors of the world who then do not return to their own countries, or organizing training without adequate concern for promoting infrastructure for them at home, will serve to undermine the role of the U.S. education sector as a tool for global sustainable development.

On Earth Day 1994, Vice President Gore announced the Global Learning and Observations to Benefit the Environment (GLOBE) program. GLOBE is an international environmental education and science effort designed to enable students, educators, and scientists to work together to monitor the global environment and provide information for developing a worldwide environmental database. The GLOBE program, with participating schools around the world, will allow students to perform environmental measurements that will greatly augment Earth observations from existing satellite and ground-based systems. Scientists and educators are working together to design experi-

The Global Information Infrastructure and Sustainable Development

The Global Information Infrastructure (GII) has an important role to play in sustainable development. The GII fosters dialogue between nations and ethnic groups and enables applications such as collaborative scientific research, distance learning, telemedicine, and electronic commerce. Electronic networking is transforming communications and the conduct of research around the world. While this transformation is fastest in the industrialized world, it is taking place in the developing world as well.

Facilitating services and research. HealthNet in Africa links physicians, researchers, medical educators, and other health care workers to their colleagues abroad. ARCCNET (African Regional Centre for Computing Network) serves as a platform for computer training and research, facilitating cooperation and improved linkages between the computer industry, academia, and policy making institutions.

Improving management of natural resources. The United States Geological Survey is providing computer hardware, software, and technical support to establish Geographic Information System (GIS) facilities at different sites in the world through cooperative programs. These facilities compile, digitize, analyze, and distribute geologic, environmental, and related information to support programs in energy and mineral resources, sustainable economic development, and environmental protection.

Strengthening healthcare. By linking hospitals around the world to the United States on the Internet, the United States Centers for Disease Control share information on, and create databases for, communicable diseases.

Promoting scientific advances. In conjunction with the International Research and Exchanges Board (IREX), the United States Information Agency intends to bring Newly Independent States (NIS) scholars and members of non-governmental organizations and related professional and governmental groups in contact with one another and link them into international databanks via computer communications. For example, a group of 60 Russian educators visiting the United States in 1995 will be linked to their American colleagues and one another through an IREX electronic mail network upon their return to Russia.

The goal of the Administration's GII initiative is to foster the communication and cooperation that will be needed to spur the transformation of a thousand discrete networks in the developed and developing worlds into a connected, interoperable global information infrastructure.

ments that will provide hands-on science and mathematical experience for elementary through high school students and generate useful environmental data for scientists.

An Environmental Technology Strategy

Not only knowledge but also appropriate technology must be promoted if we are to foster global sustainability. The Clinton Administration has crafted a forward-looking environmental technology strategy that should allow us to move expeditiously toward sustainable development. The result of working with thousands of stakeholders over two years to identify a core set of five themes to guide future activities, this national strategy is presented in the Administration document, Bridge to a Sustainable Future. The five themes are designed to establish a framework for partnerships, goal setting, policy development, and action. Within each theme, a series of findings, goals, and initiatives have been identified that together articulate a technological path leading toward sustainable development. The agencies of the Federal Government are developing specific action plans for implementing this strategy, but industry, labor, communities, non-governmental organizations, individuals, state governments, and nations around the world all have important responsibilities as well. The key to progress is to build on the strengths of each sector in order to achieve goals collectively that cannot be achieved individually.

Broadly, the five themes of the strategy comprise: (1) the development of a new generation of incentive-based policies and programs that stress performance, flexibility, and accountability; (2) shifting from reacting to environmental damage to anticipating and avoiding it; (3) supporting investment in and the diffusion of successful technologies; (4) moving rural and urban communities toward sustainability; and (5) building more effective, open, and productive collaboration among stakeholders.

Specific goals of the national environmental technology strategy include improving substantially the nation's environmental monitoring data and information systems over the next five years through public-private partnerships designed to share information essential for sustainable development, and promoting the use of environmentally sound and socially appropriate technologies in developing nations throughout the world.

Responding to Global Threats

A strategy of sustainable development and preventive diplomacy also requires a robust response to global threats such as emerging or reemerging infectious diseases, climate change, and biodiversity loss. Whereas natural disasters threaten sustainable development in a particular nation or region in a catastrophic manner, these other threats are potentially global in scope but may have onsets that take years or decades to become apparent or build these global threats.

Infectious Diseases

Modern transportation, international trade, and population shifts all contribute to the spread of diseases in developed and developing countries. As a result, infectious diseases that originate in distant parts of the world represent a potential health risk to U.S. citizens. Early detection and vigorous intervention efforts are essential to containing new and reemerging diseases before they spread. In the United States and in other industrialized nations, however, the majority of health care funds pay for treatment of those who are already ill. **The key to dealing effectively with new or re-emerging infectious diseases is global surveillance and response, and basic biomedical research.**

Infectious diseases can prevent U.S. troops operating abroad from being an effective fighting force. Techniques to prevent, detect, and control these diseases are important to keeping our troops healthy.

A well-designed surveillance program can detect and track unusual clusters of illness and establish their geographic and demographic characteristics. Effective surveillance and prevention strategies must be based on an understanding of the complex interactions between humans and microbes as well as an understanding of the evolutionary and genetic factors that cause epidemics.

The Administration is putting into place a national response to the threat of infectious diseases. While continuing to support research and training in basic and applied research to support U.S. leadership in disease surveillance, the United States will strengthen its ability to respond to epidemics by increasing U.S. "surge" capacity for the emergency production of diagnostic tests, drugs, and vaccines. Internationally, the United States will work with multilateral organizations and other countries to improve worldwide disease surveillance, reporting, and response, encouraging other countries to make infectious disease detection and control national priorities. U.S. Government laboratories and field stations abroad will be coordinated to form regional hubs in a global disease surveillance system. Our ultimate goal is to foster the creation of a worldwide disease surveillance and response network.

Climate Change

In 1992 the United States joined the international community in signing the Framework Convention on Climate Change. It was a treaty that called on all nations to work together to protect the global environment. Specifically, the industrialized countries were urged to take the lead by stabilizing greenhouse gas emissions to 1990 levels by the year 2000. Soon after taking office, the Administration went beyond the nonbinding language of the treaty to declare that the United States would meet this goal.

The Administration has developed a plan aimed at fulfilling this commitment. The government has signed voluntary agreements with the bulk of the U.S. utility industry to keep greenhouse gas emissions down. Similar partnerships have been forged with U.S. industry on energy-efficient computers, buildings, and lighting systems. The Administration has launched a partnership for a new generation of vehicles—the Clean Car Initiative. And the United States has pledged $430 million to the Global Environmental Facility (GEF) for its second phase, the largest contribution of any nation in the world.

The Importance of Surveillance Systems for Infectious Diseases

The outbreaks of Ebola in Zaire and plague in India have emphasized the importance of national and international surveillance and response capabilities to infectious diseases. Our past experience has demonstrated that allowing surveillance capabilities to dwindle may have serious consequences. Prevention or early intervention is both more humane and less expensive than mounting a late, emergency response.

For example, for many years the United States had in place a surveillance system to monitor cases of tuberculosis (TB). However, during the 1980s Federal and local spending on infectious disease control declined, and in 1986 the surveillance system for multi-drug-resistant TB was discontinued. Consequently, there was no warning signal when drug-resistant TB emerged in the late 1980s. This lack of early warning undoubtedly contributed to the more than $700 million in direct costs for TB treatment incurred in 1991 alone. Surveillance of drug-resistant TB was not reinstated until 1993, by which time multi-drug-resistant TB had become a public health crisis and millions of Federal dollars had been allocated.

AIDS is a new disease that was unknown before the 1980s and thus was not on any surveillance lists. AIDS weakens the immune system, allowing other infections to take hold. Therefore, it can be difficult to diagnose, since its clinical presentation may involve a variety of symptoms, and its incubation period (the time between infection and the appearance of symptoms) is several years. Nevertheless, long before AIDS was diagnosed in the United States and Europe, a distinct syndrome called Slim Disease (now known to be a form of AIDS) that causes its victims to waste away was recognized by African doctors. In fact, an aggressive, Slim-associated, generalized form of Kaposi's sarcoma, distinct from the classical form, has been described in Uganda since at least 1962. If a global surveillance system with the capacity to identify new diseases had been in place in the 1970s, AIDS might have been identified earlier, perhaps before it became well established in the United States. Epidemiologists might have gained a headstart in learning how AIDS is transmitted and prevented, and many lives might have been saved.

But in addition to these action-oriented steps, the Administration also recognizes that our understanding of climate change and other environmental issues rests on fundamental research, the data for which must come from comprehensive observations. The Administration has therefore identified environmental observations and data management as an area to receive enhanced emphasis.

Observations and Data Management

Extensive Earth observation and monitoring are a critical component of environmental and natural resource research aimed at advancing scientific understanding and developing predictive capabilities. The coordination of observation and data management efforts ensures that the data necessary to answer the questions of highest priority to both scientists and policy makers are being gathered and distributed and that U.S. efforts are taking full advantage of, and being sufficiently coordinated with, international efforts.

The Administration has identified four areas for enhanced emphasis: (1) linking local-scale data collection efforts to regional- and global-scale efforts; (2) linking remote sensing data from satellites to in situ measurements; (3) linking socioeconomic data to data on the natural environment; and (4) making Federal agency environmental data and information available in forms useful to the public, educators, policy makers at all levels, business activities, and researchers.

Although the United States and many other nations are collecting critical environmental and natural resource data, successfully understanding many aspects of environmental science will require the implementation of an international policy of open and stable exchange of data and information. The United States promotes the continuance and extension of the full and open exchange of all environmental data and related information at no more than the marginal cost of fulfilling specific user requests.

Finally, the Administration is acting to put hard-won and expensive data collected during the Cold War to the service of environmental understanding. Following a Presidential Executive Order, some 800,000 spy satellite photographs taken between 1960 and 1972 are to be released. Selectively declassifying information gathered during the Cold War will allow these images to shed new light on the progression of deforestation, the loss of fresh water, desertification, and other issues.

Biodiversity and Ecosystem Research

In June 1993, the United States signed the Convention on Biological Diversity, which aims to protect and utilize the world's genetic inheritance. The Interior Department has been directed to create a national biological survey to help protect species and to help the agricultural and biotechnology industries identify new sources of food, fiber, and medications.

The Administration has set a goal of developing the understanding of ecological systems necessary for assessing the ecological consequences of environmental change. This goal will promote the efficient use of natural resources, while sustaining ecosystem integrity for future generations by developing science-based management principles and a predictive understanding of the ecological impacts of environmental change.

It is imperative that we understand and quantify the drivers of change in ecological systems. Understanding the importance of the influence and magnitude of different drivers of change is critical to developing strategies for sustainable development. To this end, the Administration has identified six areas for enhanced emphasis in ecosystem research: (1) documenting change in ecological systems; (2) understanding processes in ecological systems; (3) synthesizing and assessing ecological data and information; (4)

predicting ecological change; (5) understanding the interactions of human and ecological systems; (6) and the restoration, rehabilitation, and management of ecological systems.

An example of the Administration's increased emphasis on ecosystem research, and its importance for preserving biodiversity, is provided by the Coral Reef Initiative. **The declining health of coral reef ecosystems links the larger issues of climate change and increased stress from human population growth**. Some scientists estimate that 10 percent of reefs have already been degraded beyond recovery, and that 10 to 20 percent more could be gone by the year 2010. Not only does this mean the loss of a large fraction of the ocean's most biodiverse ecosystems, but also this decline is bad for tourism and fisheries, and hence for development. To address this degradation, the U.S. Government is forming partnerships with states and territories, other nations, multilateral development banks, and non-governmental organizations. The Initiative's goal is to enable countries to use existing resources to sustainably manage coral reef ecosystems over the long term.

Socioeconomic Dimensions

The social and economic sciences represent a critical component of any research agenda on environmental change. Research in the social and economic sciences aims to clarify how human activities affect the environment; how environmental changes affect our society and its component groups; and how we and our institutions respond to environmental change.

Long-term research is needed on human-environmental interactions and system dynamics. Their complexity requires greater collaboration of physical, life, and engineering scientists with social scientists than usually prevails. The Administration has identified three research areas for enhanced emphasis: (1) fundamental human and social processes that affect our use of the Earth; (2) the development of a better portfolio of policy instruments and decision tools; and (3) improving the flow of information between the research and policy communities and within the public and private sectors.

Science Policy Tools

Science policy tools for decision making provide the links between the physical, natural, social, and economic sciences and environmental policy. Technical assessments are key tools in formulating national and international environmental policies. To be useful, however, these assessments must be credible to all stakeholders, including the Administration, Congress, industry, non-governmental organizations, and the public.

The Administration's goal is to use assessment methods to characterize, prevent, and reduce health and environmental hazards in the most effective, efficient, and fair manner. The Administration is committed to strengthening the methods used to perform risk and integrated assessments of health and environmental hazards.

Strategic International Cooperation

As a world leader in science and technology, the United States has an opportunity to apply its science and technology capabilities to support international initiatives that benefit the United States and the global community. To realize this potential, the Office of Science and Technology Policy is developing strategies for cooperation with other nations-"country strategies"-placing a priority on those that are key to the stability of their region, have the scientific and technological base to attract long-term investments and trade, and offer emerging markets for U.S. goods and services. By strengthening the progress of science and technology and the communities of researchers and scholars, international cooperation can contribute to positive political and economic reform, regional stability, sustainable development, and economic growth.

American Diplomacy and the Global Environmental Challenges of the 21st century

Warren Christopher
Secretary of State
Address and Question and Answer Session at
Stanford University, Palo Alto, California
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Thank you very much for that kind introduction. I am especially honored to be introduced by Gerhard, whom I have known and admired in his various incarnations, especially his current one. Even putting aside my personal ties, I can think of no better venue for my remarks today on global environmental issues than this university. From the founding of the Sierra Club in 1892 to the first Earth Day in 1970, Stanford faculty and alumni have led efforts to preserve our country's natural resources for future generations. Your centers for Conservation Biology and Global Ecosystem Function have done pioneering work. Let me also say that I am personally grateful for the continuing work of Coach Montgomery and Coach Willingham to keep the California Bear population under control.

With strong leadership from President Clinton and Vice President Gore, our Administration has recognized from the beginning that our ability to advance our global interests is inextricably linked to how we manage the Earth's natural resources. That is why we are determined to put environmental issues where they belong: in the mainstream of American foreign policy. I appreciate and value this opportunity to outline our far-reaching agenda to integrate fully environmental objectives into our diplomacy, and to set forth our priorities for the future.

The environment has a profound impact on our national interests in two ways: First, environmental forces transcend borders and oceans to threaten directly the health, prosperity and jobs of American citizens. Second, addressing natural resource issues is frequently critical to achieving political and economic stability, and to pursuing our strategic goals around the world.

The United States is providing the leadership to promote global peace and prosperity. We must also lead in safeguarding the global environment on which that prosperity and peace ultimately depend.

In 1946, when I came to Stanford as a law student, the connection between the environment and foreign policy was not so readily apparent. At home, Americans were entering a period of unprecedented prosperity fueled by seemingly infinite resources. Abroad, we were beginning to focus on the struggle between the United States and the Soviet Union. And I was trying to master the intricacies of contracts, torts, and something called remedies, taught by Stanford's version of John Houseman. I was also trying to measure up to the high standards set by a new young Dean, Carl Spaeth, who had just come to Stanford from a very promising career at the State Department, and who first stimulated my interest in the work in which I am now engaged full time.

But since 1946, population growth, economic progress, and technological breakthroughs have combined to fundamentally reshape our world. It took more than 10,000 generations to reach a world population of just over two billion. In just my lifetime — a period that may seem like an eternity to many of the students in the audience — the world's population has nearly tripled to more than five-and-a-half billion.

These changes are putting staggering pressures on global resources. From 1960 to 1990, the world's forests shrank by an amount equivalent to one-half the land area of the United States. Countless species of animals and plants are being wiped out, including many with potential value for agriculture and medicine. Pollution of our air and water endangers our health and our future.

In carrying out America's foreign policy, we will of course use our diplomacy backed by strong military forces to meet traditional and continuing threats to our security, as well as to meet new threats such as terrorism, weapons proliferation, drug trafficking and international crime. But we must also contend with the vast new danger posed to our national interests by damage to the environment and resulting global and regional instability.

As the flagship institution of American foreign policy, the State Department must spearhead a government-wide effort to meet these environmental challenges. Together with other government agencies, we are pursuing our environmental priorities — globally, regionally, bilaterally, and in partnership with business and non-governmental organizations. Each of these four dimensions is essential to the success of our overall strategy.

First, our approach to these problems must be global because pollution respects no boundaries, and the growing demand for finite resources in any part of the world inevitably puts pressure on the resources in all others.

Across the United States, Americans suffer the consequences of damage to the environment far beyond our borders. Greenhouse gases released around the globe by power plants, automobiles and burning forests affect our health and our climate, potentially causing many billions of dollars in damage from rising sea levels and changing storm patterns. Dangerous chemicals such as PCBs and DDT that are banned here but still used elsewhere travel long distances through the air and water. Over fishing of the world's oceans has put thousands of Americans out of work. A foreign policy that failed to address such problems would be ignoring the needs of the American people.

Each nation must take steps on its own to combat these environmental threats, but we will not succeed until we can effectively fight them together. That realization inspired the path breaking efforts of the United Nations at the Stockholm Conference on the Human Environment 25 years ago, and at the historic Rio Summit on Environment and Development four years ago. There, the international community forged a new global commitment to "preserve, protect and restore...the Earth's ecosystem" and to promote economic development in ways that also preserve our natural resources.

Since Rio, the United States has intensified our global efforts. We led the way to an agreement to phase out the remaining substances that damage the ozone layer, to ban the ocean dumping of low-level radioactive waste, and to achieve a new consensus in Cairo on stabilizing global population growth.

We are working to reform and strengthen the UN's key environmental and sustainable development programs. We have joined forces with the World Bank to incorporate sound environmental policies in lending programs, and to fund projects through the Global Environment Facility that directly benefit our health and prosperity. And we are striving through the new World Trade Organization to reconcile the complex tensions between promoting trade and protecting the environment — and to ensure that neither comes at the expense of the other.

This year, we will begin negotiating agreements with the potential to make 1997 the most important year for the global environment since the Rio Summit. We will seek agreement on further cuts in greenhouse gases to minimize the effects of climate change. We will help lead an international process to address the problems caused by toxic chemicals that can seep into our land and water, poisoning them for generations. We will develop a strategy for the sustainable management of the world's forests — a resource that every great civilization has discovered is "indispensable for carrying on life," as the Roman historian Pliny once wrote. We will work with Congress to ratify the Biodiversity Convention, which holds benefits for American agriculture and business. We will also seek ratification of the Law of the Sea Treaty, which safeguards our access to ocean resources. We will provide the leadership needed to ensure that this June's UN Summit in Istanbul effectively confronts the pressing problems associated with the explosive growth of cities in the developing world.

Finally, by the end of 1997, the State Department will host a conference on strategies to improve our compliance with international environmental agreements — to ensure that those agreements yield lasting results, not just promises.

This is a daunting global agenda. Achieving these goals will take time and perseverance. But I often remember Don Kennedy's advice to graduates to set a "standard higher than you can comfortably reach."

The second element of our strategy — the regional element — is to confront pollution and the scarcity of resources in key areas where they dramatically increase tensions within and among nations. Nowhere is this more evident than in the parched valleys of the Middle East, where the struggle for water has a direct impact on security and stability. In my many trips to the region, I have seen how rapid population growth and pollution can raise the stakes in water disputes as ancient as the Old Testament. As Shimon Peres once remarked to me, "The Jordan River has more history in it than water." We are helping the parties in the Middle East peace process to manage the region's water resources — to turn a source of conflict into a force for peace.

There can be no doubt that building stable market democracies in the former Soviet Union and Central Europe will reinforce our own security. However, for these new nations to succeed, we must help them overcome the poisonous factories, soot-filled skies and ruined rivers that are one of the bitter legacies of communism. The experience of this region demonstrates that governments that abuse their citizens too often have a similar contempt for the environment.

The United States also has an enormous stake in consolidating democratic institutions and open markets in our own hemisphere. To deepen the remarkable transformation that is taking place across Latin America and the Caribbean, we are advancing the agenda for sustainable development that our 34 democracies adopted at the Miami Summit of the Americas. To help democracy succeed, for example, we must ease the pressures of deforestation and rapid population growth that I have seen at work in the bare hills and crowded city streets of Haiti. To sustain our prosperity, we must work to preserve the rich diversity of life that I saw in the Amazon rainforest. To help heal the wounds of old conflicts, we must reverse the environmental damage that has narrowed economic opportunities and fueled illegal immigration from El Salvador. And to help combat drug trafficking and crime, we are encouraging sustainable agriculture as an alternative to the slash-and-burn cultivation of opium poppies and coca from Guatemala to Colombia. These goals will be high on our agenda at the Sustainable Development Summit this December in Bolivia.

In Africa, we are pursuing environmental efforts designed to save tens of thousands of lives, prevent armed conflict, and avert the need for costly international intervention. Our Greater Horn of Africa Initiative, for example, addresses the root causes of environmental problems that can turn droughts into famines, and famines into civil wars. We must not forget the hard lessons of Rwanda, where depleted resources and swollen populations exacerbated the political and economic pressures that exploded into one of this decade's greatest tragedies. We also have a national interest in helping the nations of the region address the AIDS crisis, which is decimating a whole generation of young Africans and wasting the economic resources that African nations so desperately need to build stable governments and a brighter economic future.

To intensify our regional environmental efforts, we will establish Environmental Hubs in our embassies in key countries. These will address pressing regional natural resource issues, advance sustainable development goals, and help U.S. businesses to sell their leading-edge environmental technology.

The third element of our strategy is to work bilaterally with key partners around the world — beginning, of course, with our next-door neighbors. Whether it is fishing on the Georges Bank or in the Gulf of Mexico, or clean drinking water from the Great Lakes or the Rio Grande, we cannot separate our environmental interests from those of Canada or Mexico.

We are extending our century-old cooperation with Canada on behalf of clean water and flood control in the Great Lakes region. We are improving conservation in our adjoining national park lands. Through the U.S.-Canada Joint Commission, we are protecting human health and natural habitats. And with all our Arctic neighbors, we are establishing a partnership to protect that fragile region.

Our joint efforts with Mexico have grown in importance since NAFTA took effect just over two years ago. Under the NAFTA side agreements on the environment, we have set up new institutions to help communities on both sides of the border safeguard the natural resources they share. Later this spring, we will launch an innovative program that will enable business and government leaders from Texas, New Mexico, and Ciudad Juarez to reduce some of the region's worst air pollution. When our two nations' cabinets meet in Mexico City next month, I will emphasize the importance of Mexico continuing to strengthen its environmental standards.

Through our Common Agenda with Japan, the world's two largest economies are pooling their resources and expertise to stabilize population growth, to eradicate polio, to fight AIDS, and to develop new "green" technology.

Our New Transatlantic Agenda with the European Union will spur global efforts on such issues as climate change and toxic chemicals. Together, we are already advancing our environmental goals in Central Europe and the New Independent States.

Russia and China are both confronting major environmental problems that will have a profound effect on their future — and on ours.

In Russia, the fate of democracy may depend on its ability to offer the Russian people better living standards and to reverse a shocking decline in life expectancy. From Murmansk to Vladivostok, poorly stored nuclear waste poses a threat to human life for centuries to come. Economic reforms will not meet their potential if one-sixth of the Russian land mass remains so polluted that it is unfit even for industrial use, and if Russian children are handicapped by the poisons they breathe and drink.

We are cooperating with Russia to meet these challenges. Ten days from now, President Clinton will join President Yeltsin and other leaders at a Nuclear Safety Summit in Moscow, which will promote the safe operation of nuclear reactors and the appropriate storage of nuclear materials. Vice President Gore and Prime Minister Chernomyrdin are spearheading joint initiatives to preserve the Arctic environment, reduce greenhouse gases, and promote the management of key natural resources. We are even taking the satellite imagery once used to spot missiles and tanks and using it to help clean up military bases and track ocean pollution.

As we discussed this morning at your Institute for International Studies, the environmental challenges that China faces are truly sobering. With 22 percent of the world's population, China has only seven percent of its fresh water and cropland, three percent of its forests, and two percent of its oil. The combination of China's rapid economic growth and surging population is compounding the enormous environmental pressures it already faces. That is one of the many reasons why our policy of engagement with China encompasses the environment. Later this month, Vice President Gore will launch an initiative that will expand U.S.-China cooperation on sustainable development, including elements such as energy policy and agriculture.

In our other bilateral relationships, we have created partnerships that strengthen our ties while moving beyond the outdated thinking that once predicted an inevitable struggle between North and South. Under the Common Agenda for the Environment we signed last year with India, for example, we are cooperating on a broad range of shared interests from investing in environmental technologies to controlling pesticides and toxic chemicals. During my trip to Brazil last month, we strengthened a similar Common Agenda with agreements on cooperation in space that will widen our knowledge about climate change and improve management of forest resources.

The fourth and final element of our strategy reinforces these diplomatic approaches by building partnerships with private businesses and non-governmental organizations.

American businesses know that a healthy global environment is essential to our prosperity. Increasingly, they recognize that pitting economic growth against environmental protection is what President Clinton has called "a false choice." Both are necessary, and both are closely linked.

Protecting the environment also opens new business opportunities. We are committed to helping U.S. companies expand their already commanding share of a $400 billion market for environmental technologies. This effort was one of many championed by my late colleague and friend, Commerce Secretary Ron Brown. His last mission to Africa helped an American firm win a contract that will protect fisheries and fresh water supplies for 30 million people in Uganda, Tanzania and Kenya. On my recent visit to El Salvador, I met with U.S. firms, non-governmental organizations and their Central American partners who are pioneering the use of solar and wind power stations.

Non-governmental organizations working with USAID have played a crucial role in advancing our environmental objectives overseas. For many years, for example, the Sierra Club has been deeply engaged in international population efforts and it made an important contribution to the Cairo Conference. As part of these joint efforts, the World Wildlife Fund is helping to conserve biodiversity in more than 40 countries, the World Resources Institute is confronting deforestation in Africa, and the Nature Conservancy is protecting wildlife preserves across Latin America. Through the State Department's new "Partnership for Environment and Foreign Policy," we will bring together environmental organizations, business leaders and foreign policy specialists to enhance our cooperation in meeting environmental challenges.

It is the responsibility of the State Department to lead in ensuring the success of each one of the four elements of the strategy that I have discussed today—global, regional, bilateral and partnerships with business and NGOs. Working closely with the President and the Vice President, I have instructed our bureaus and our embassies to improve the way we use our diplomacy to advance our environmental objectives.

We will raise these issues on every occasion where our influence may be useful. We will bolster our ability to blend diplomacy and science, and to negotiate global agreements that protect our health and well-being. We will reinforce the role of the Under Secretary for Global Affairs which was created at the beginning of our Administration to address transnational issues. We will strengthen our efforts with USAID to promote sustainable development through effective environment and family planning assistance. And we will reinforce the environmental partnerships that we have formed with the EPA, and the departments of Defense, Energy, Commerce, Interior and Agriculture.

In addition, I am announcing today that starting on Earth Day 1997, the Department will issue an annual report on Global Environmental Challenges. This report will be an essential tool of our environmental diplomacy, bringing together an assessment of global environmental trends, international policy developments, and U.S. priorities for the coming year.

Our strength as a nation has always been to harness our democracy to meet new threats to our security and prosperity. Our creed as a people has always been to make tomorrow better for ourselves and for our children. Drawing on the same ideals and interests that have led Americans from Teddy Roosevelt to Ed Muskie to put a priority on preserving our land, our skies and our waters at home, we must meet the challenge of making global environmental issues a vital part of our foreign policy. For the sake of future generations, we must succeed.

Thank you very much.

Preventive Defense

Remarks as Prepared for Delivery by
William J. Perry
Secretary of Defense
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Harvard University
May 13, 1996

In a famous 1837 lecture at Harvard, Ralph Waldo Emerson asked his audience, "If there is any period one would desire to be born in, is it not the age of Revolution, when the old and the new stand side by side, when the energies of all men are searched by fear and by hope, when the historic glories of the old can be compensated by the rich possibilities of the new?"

Like Emerson, we, too, live in an age of revolution: In politics, with the ending of the Cold War; in economics, with the dramatic growth in global trade; and in technology, with the continuing explosion of information systems. Today, we are living Emerson's desire in a revolutionary era of "rich possibilities," an era when our energies are "searched by fear and by hope." Our hope is symbolized by the success of democracy around the globe, by the growth of new global trade relationships, by the expansion of global communications, and by the explosion of information. Indeed, in this revolutionary new era, the term "closed society" is rapidly becoming obsolete. Even those states that still desire isolation find it increasingly difficult to achieve. Indeed, it is impossible to achieve if they want to reap the benefits of the global economy, as China discovered during the Tiananmen Square crackdown, when they could not control the fax machines and modems.

But along with this hope, our energies in this revolutionary era are also "searched by fear": Fear of the proliferation of weapons of mass destruction; fear of ethnic hatreds ripping asunder existing states; fear of terrorism by extremist groups; and fear of aggression by rogue nations freed from the constraints of their former Cold War alliances. For many, this revolutionary new era has meant a decreased sense of personal safety, symbolized by pictures of the bodies being carried from the Federal building in Oklahoma or of the gassed passengers rushing from a Tokyo subway.

The stark contrast between our hopes and our fears makes clear that this revolutionary new era is characterized by the increased capacity of humankind for good and for evil. It also makes clear that in addition to revolutions in politics, economics and technology, there must also be a revolution in our thinking about security strategy.

The security of the United States continues to require us to maintain strong military forces to deter and, if necessary, to defeat those who threaten our vital national interests — and we do. But today, the United States also has a unique historical opportunity, the opportunity to prevent the conditions for conflict and to help create the conditions for peace. Today, I want to talk to you about how America's security policy in the post-Cold War era requires us to take advantage of that opportunity: to make "preventive defense" the first line of defense of America, with deterrence the second line of defense, and with military conflict the third and last resort.

Preventive defense may be thought of as analogous to preventive medicine. Preventive medicine creates the conditions which support health, making disease less likely and surgery unnecessary. Preventive defense creates the conditions which support peace, making war less likely and deterrence unnecessary.

Twice before in this century, America has had similar opportunities to prevent the conditions for conflict. After World War I, the United States had the opportunity to help prevent conflict by joining the League of Nations and engaging the world. Instead, we chose to isolate ourselves from the world. That strategy of isolationism, coupled with the Europeans' strategy of reparations and revenge, utterly failed to prevent the conditions for future conflict. In fact, it helped create them. And over three hundred thousand Americans paid with their lives in a second World War. After World War II, America was determined to learn from that costly lesson — this time we chose the path of engagement. We sought to prevent conflict from recurring. Through our engagement in the United Nations and by our leadership, we promoted a post-war program of reconciliation and reconstruction, in sharp contrast to the reparation and revenge practiced after World War I. Our most dramatic national effort to prevent future conflict was announced at Harvard's 1947 commencement by George C. Marshall. It came to be called the Marshall Plan.

Marshall acted at a pivotal moment in this century. Like Emerson, Marshall saw America in a world standing between two eras, a period Marshall described as "between a war that is over and a peace that is not yet secure." At this pivotal moment, Marshall set forth a strategy of preventive defense. The soldier in Marshall wanted desperately to prevent war from recurring — the statesman in Marshall found a way. His vision was of a Europe — from the Atlantic to the Urals — united in peace, freedom and democracy. His tool for realizing his vision was a plan for rebuilding a European continent that had been physically, economically and spiritually shattered by war.

The Marshall Plan rested on three premises: That what happens in Europe affects America; that economic reconstruction in Europe was critical to preventing another war; and that economic reconstruction of Europe would not happen without US leadership. Acting on these premises, Marshall and his generation rebuilt Europe and they led America to assume the mantle of world leadership. Their preventive defense program was successful in creating the conditions of peace and stability wherever applied.

In the end, however, Marshall's vision was only half realized, because Joseph Stalin slammed the door on Marshall's offer of assistance. Within a matter of years, the world was divided into two armed camps. And deterrence, not prevention, became the overarching security strategy of the Cold War. While geopolitics doomed Marshall's efforts at preventive security for Europe, the technology of nuclear weapons made a global war too terrible to contemplate — so deterrence worked. Now, after more than forty dangerous years of the nuclear balance of terror, the Cold War is over.

Today, we are at another pivotal moment in history, a point between two centuries — a point between a Cold War that is over and a peace that is not yet secure. Today, the world does not need another Marshall Plan. But to ensure that it is our hopes and not our fears that will be realized in this revolutionary age, we do need to build on Marshall's core belief that the United States must remain a global power, and that our best security policy is one which prevents conflict.

Just as the Marshall Plan was based on a set of premises, so today our program of preventive defense rests on its own set of premises. First, that fewer weapons of mass destruction in fewer hands makes America and the world safer. Second, that more democracy in more nations means less chance of conflict in the world. And third, that defense establishments have an important role to play in building democracy, trust and understanding in and among nations.

From these premises follows the conclusion that for the post-Cold War world to be one of peace, and not conflict, America must lead the world in preventing the conditions for conflict and in creating the conditions for peace. In short, we must lead with a policy of preventive defense. So we have created an innovative set of programs in the Defense Department to do just that — some national, some international. They include: The Cooperative Threat Reduction program to reduce the nuclear weapon complex of the nuclear nations of the former Soviet Union; the counter- proliferation program to deal with the threat of the proliferation of weapons of mass destruction; the Framework Agreement to eliminate the nuclear weapons program of North Korea; and the Partnership for Peace to begin the integration of 27 nations of Eastern and Central Europe and Central Asia into the European security structure. I will describe the progress in some of these programs, and how they are, in fact, creating conditions which prevent conflict.

Nowhere is preventive defense more important than in countering the spread of nuclear, chemical and biological weapons. During the Cold War, the world lived with the nightmare prospect of global nuclear holocaust, and the United States and the Soviet Union relied on deterrence, a balance of terror known as Mutual Assured Destruction, or MAD. Today, the threat of global nuclear holocaust is vastly reduced, but we face the new danger that weapons of mass destruction will fall into the hands of terrorist groups or rogue states. The threat of retaliation may not matter much to a terrorist group or a rogue nation — deterrence may not work with them. This new class of "undeterrables" may be madder than MAD.

The aspiration of these rogue nations to obtain weapons of mass destruction is set against the backdrop of the disintegration of the former Soviet Union. This disintegration meant that instead of one nuclear empire, we were left with four new states, each with nuclear weapons on their soil: Russia, Kazakstan, Ukraine, and Belarus. The depressed economies of these nations created a buyer's market for weapons of mass destruction, including the materials, infrastructure, and work-force, and the unsettled political conditions made it potentially harder to protect those weapons and materials.

The increase in demand for nuclear weapons, and the potential increase in supply of weapons, material and know-how have required us to augment our Cold War strategy of deterrence with a post-Cold War strategy of prevention. The most effective way to prevent proliferation is to dismantle the arsenals that already exist. Fortunately, through our Cooperative Threat Reduction program with Russia and the other nuclear states of the former Soviet Union, we have the dismantlement well started. Through a defense program created by Senators Sam Nunn and Richard Lugar, we have helped Russia, Ukraine, Belarus and Kazakstan dismantle thousands of nuclear warheads and destroy hundreds of missiles, bombers and silos. This January, I personally detonated an SS-19 silo at Pervomaysk, which once had 700 nuclear warheads aimed at targets in the United States. By the end of the month, this missile field will have been converted to a wheat field. By the end of the year, Kazakstan, Ukraine and Belarus will be entirely free of nuclear weapons. We are also using Nunn-Lugar funds to help these nations safeguard and secure the weapons and materials to keep them out of the global marketplace. Under Project Sapphire, for example, we bought 600 kg of highly enriched uranium from Kazakstan to ensure that it did not fall into the hands of nuclear smugglers.

But preventing proliferation means more than just dismantling the Cold War nuclear arsenals. It also means leading the world in the right direction, as we did last year in gaining a consensus for the indefinite extension of the Nuclear non-Proliferation Treaty. It means working to strengthen the Biological Weapons Convention and ratifying the Chemical Weapons Convention. It means taking the lead in a range of international export controls to limit the flow of goods and technologies that could be used to make weapons of mass destruction. During the Cold War, for example, we had the COCOM regime of export controls, designed to prevent the spread of dangerous technologies to the Soviet Union and Eastern Bloc. Today, we are creating the Wassenaar regime, set-up in cooperation with Russia, updated to fit today's technology and designed to prevent the spread of dangerous technologies to potential proliferators and rogue regimes.

Preventing proliferation also means leading the international community in opposing rogue nations with nuclear and/or chemical weapon aspirations, such as Iran and Libya. Economic sanctions and export controls have helped prevent Iran from acquiring nuclear weapons and they have significantly slowed Libya's efforts to put a chemical weapons production plant into operation.

Sometimes preventing proliferation means employing "coercive diplomacy" — a combination of diplomacy and defense measures. In North Korea, for example, we used such a combination to stop that nation's nuclear weapons program. The diplomacy came from the threat by the United States and other nations in the region to impose economic sanctions if North Korea did not stop their program and the promise of assistance in the production of commercial power if they did. The defense came from our simultaneous beefing up of our military forces in the region. The result is that today, while North Korea continues to pose a conventional military threat on the peninsula, it is not mounting a nuclear threat.

Overall, the United States has been instrumental in eliminating or reversing nuclear weapon programs in six states since 1991: Ukraine, Belarus, Kazakstan, Iraq, North Korea and South Africa. These efforts have made both America and the world safer; and the gains to our national security have been dramatic, direct and tangible. I can think of few more satisfying moments in my life than when I turned the key to blow up that missile silo in Pervomaysk.

But the story of preventive defense is not merely one of preventing threats from weapons of mass destruction. It is also the story of engaging military and defense establishments around the world to further the spread of democracy and to further trust and understanding among nations. Here, the results may be less immediately tangible, but they are no less significant.

America has long understood that the spread of democracy to more nations is good for America's national security. It has been heartening this past decade to see so many nations around the world come to agree with us that democracy is the best system of government. But as the nations of the world attempt to act on this consensus, we are seeing that there are important steps between a world-wide consensus and a world-wide reality. Democracy is learned behavior. Many nations today have democracies that exist on paper, but, in fact, are extremely fragile. Elections are a necessary but insufficient condition for a free society. It is also necessary to embed democratic values in the key institutions of nations.

The Defense Department has a key role to play in this effort. It is a simple fact that virtually every country in the world has a military. In virtually every new democracy — in Russia, in the newly free nations of the former Soviet Union, in Central and Eastern Europe, in South America, in the Asian Tigers — the military represents a major force. In many cases it is the most cohesive institution. It often contains a large percentage of the educated elite and controls key resources. In short, it is an institution that can help support democracy or subvert it.

We must recognize that each society moving from totalitarianism to democracy will be tested at some point by a crisis. It could be an economic crisis, a backslide on human rights and freedoms, or a border or ethnic dispute with a neighboring country. When such a crisis occurs, we want the military to play a positive role in resolving the crisis, not a negative role by fanning the flames of the crisis — or even using the crisis as a pretext for a military coup.

In these new democracies, we can choose to ignore this important institution, or we can try to exert a positive influence. We do have the ability to influence, indeed, every military in the world looks to the U.S. armed forces as the model to be emulated. That is a valuable bit of leverage that we can put to use creatively in our preventive defense strategy.

In addition, if we can build trust and understanding between the militaries of two neighboring nations, we build trust and understanding between the two nations themselves. Some have said that "war is too important to be left solely to the generals." Preventive defense says "peace is too important to be left solely to the politicians."

In this effort, preventive defense uses a variety of tools, such as educating foreign officers at our military staff and command colleges, where they learn how to operate in a democratic society and how to operate under civilian control and with legislative oversight. Over 200 officers from the former Soviet Union and Warsaw Pact countries are right now studying at U.S. institutions, and another 60 are about to complete a special course we have set up at the Marshall Center in Germany.

Another tool is sending out teams of American military officers and civilians to help nations build modern, professional military establishments under strong civilian defense leadership. Since 1992, these teams have had thousands of contacts with dozens of newly-free nations. These contacts have led Hungary, for example, to enact new laws placing the Hungarian military under civilian, democratic control. They have helped Romania develop a new code of conduct for their military forces based on the American military's Uniform Code of Military Justice. They have helped Lithuania, Kazakstan, and Uzbekistan to improve their training for Non-Commissioned Officers.

We also use tools such as joint training exercises in peacekeeping, disaster relief and search and rescue operations. We have held four such training exercises in the last year with Russian troops — two in Russia and two in the U.S. We also held a joint peacekeeping exercise in Louisiana last July, involving troops from fourteen nations with whom we had never had security relations, including Albania and Romania, Slovakia and Slovenia, Uzbekistan and Kazakstan, and all three Baltic nations. Next month, I will meet up with the ministers of defense from Ukraine, Russia, Poland and other nations for the opening ceremonies of an exercise in Lviv, Ukraine.

Confidence-building measures are another important tool, particularly in building trust between countries. One of the most important confidence building measures is developing openness about military budgets, plans and policies. Openness is an unusual concept when it comes to defense. The art of war, after all, involves secrecy and surprise, but the art of peace involves exactly the opposite — openness and trust. That's why when I travel to newly democratic states, I try to set an example by handing out copies of my annual report to Congress, which details our defense budget and our security policies. I also talk about legislative oversight and our budget process. These concepts seem elementary to you and me, but to military officers and defense officials who grew up under totalitarianism, they are positively revolutionary.

In Europe and Central Asia, these tools of preventive defense come together in a NATO program known as Partnership for Peace, or PFP. The name "Partnership for Peace" was coined by Joe Kruzel, a former fellow at the Center for Science and International Affairs we honor today, who died while working for peace in Bosnia last August.

Through Partnership for Peace, NATO is reaching out to the nations of Eastern and Central Europe, Russia and the Newly Independent States, and truly integrating them into the security architecture of Europe. It used to be when the Secretary of Defense went to meetings at NATO headquarters in Belgium, he sat next to his counterpart from the United Kingdom. Today, when I go to meetings in Belgium, I sit with my counterpart from Uzbekistan on one side and the ministers from the United Kingdom and Ukraine on the other.

Just as the Marshall Plan had an impact well beyond the economies of Western Europe, PFP is echoing beyond the security realm in Partner nations and into the political and economic realms. PFP members are working to uphold democracy, tolerate diversity, respect the rights of minorities and freedom of expression. They are working to build market economies. They are working hard to develop democratic control of their military forces, to be good neighbors and to respect the sovereign rights of bordering countries. They are working hard to make their military forces compatible with NATO.

For those Partner countries that are embracing PFP as a path to NATO membership, these actions are a key to opening that door. For many of these nations, aspiration to NATO membership has become the rock on which all major political parties base their platforms. It is providing an overlapping consensus on a unifying goal, making compromise and reconciliation on other issues possible. To lock in the gains of reform, NATO must ensure that the ties we are creating in PFP continue to deepen and that we actually proceed with the gradual and deliberate, but steady process of outreach and enlargement to the East.

Ultimately, PFP is doing more than just building the basis for NATO enlargement. It is, in fact, creating a new zone of security and stability throughout Europe, Russia and the NIS. By forging networks of people and institutions working together to preserve freedom, promote democracy and build free markets, PFP today is a catalyst for transforming Central and Eastern Europe, much as the Marshall Plan transformed Western Europe in the ′40s and ′50s. In short, PFP is not just "defense by other means," it is "democracy by other means;" It is helping prevent the realization of our fears for the post-Cold War era and taking us closer to realizing our hopes.

One of these hopes is that Russia will participate in a positive way in the new security architecture of Europe. Russia has been a key part of the European security picture for over 300 years. It will remain a key player in the coming decades, for better or worse. The job for the United States, NATO and Russia is to make it for the better. Unlike with the Marshall Plan 50 years ago, Russia today has chosen to participate in Partnership for Peace. We welcome Russia's participation, and hope that over time it will take on a leading role in PFP commensurate with its importance as a great power.

NATO's efforts to build cooperative ties with Russia complement the bilateral efforts of the United States and Russia to build what we call a "pragmatic partnership" — another piece of preventive defense. The pragmatic partnership involves working with Russia in important areas where our interests overlap, such as Nunn-Lugar; while trying to build trust and cooperation through such things as military exchanges and joint exercises.

The immediate payoff for our joint training with the PFP nations and our efforts to build a cooperative relationship with Russia has come, ironically, in Bosnia. Up until late last year, to say that "the future history of Europe is being written in Bosnia," would have been a profoundly pessimistic statement. Today, however, this statement qualifies as guarded optimism; not only because there is satisfactory compliance with the Dayton peace agreement, but because of the way IFOR has been put together and because of the way it is performing. IFOR is not a peacekeeping exercise — it is the real thing. Fourteen Partner nations have joined NATO nations in shouldering the responsibility in IFOR. A Russian brigade is operating as part of an American division in IFOR — the top Russian commander in Bosnia, General Shevtsov, visited your Center for Science and International Affairs just last week. NATO itself has a renewed sense of purpose and sense of its own ability to put together a force for a post-Cold War military mission. This is all positive history, and it shows why I believe that Bosnia is turning out to be the crucible for the creation of Marshall's Europe.

We are also seeking to use the tools of preventive defense to prevent the occurrence of future Bosnias. Last month, I attended a conference of ministers of defense in Tirana, Albania, directed to the specific military cooperation and confidence building measures that would be most effective in building peace and stability in the South Balkans. The enthusiasm of these leaders for the tools of preventive defense made me very hopeful that we can be effective in preventing future conflict in this famously troubled region.

Our hopes for democracy and regional understanding and our opportunities to support them through the tools of preventive defense are not confined to Europe. We have these same hopes and opportunities here in our own Hemisphere. Ten years ago, Latin America was made up mostly of dictatorships, but today, 34 nations in our hemisphere — all the nations save one — are democracies. I have tried to seize this opportunity by opening relationships with the defense ministries of these countries. Our efforts came to a climax last summer when I invited the defense ministers from the other 33 hemispheric democracies to join me at Williamsburg, Virginia, to discuss confidence building measures and defense cooperation designed to minimize the risk of conflict in the hemisphere. The conference was a resounding success. As a result, today we are not only seeing increased cooperation between the U.S. and Latin American militaries, we are also seeing cooperation between and among the Latin American militaries themselves — with renewed efforts to resolve outstanding disputes peacefully and create new levels of confidence. A second hemispheric ministerial meeting is scheduled to be held in Argentina this fall.

Preventive defense also has a role in our effort to manage our relationship with China. We are using some of these same tools to build cooperative security ties between the United States and China. We do this not because China is a new democracy — it obviously is not. Rather, we do it because China is a major world power with whom we share important interests, with whom we have strong disagreements, and which has a powerful military that has significant influence on the policies that China follows. We do it, ultimately, because we believe when it comes to strategic intentions, engagement is almost always better than ignorance.

That is why we have sent teams to China to present our strategic thinking, and have invited the Chinese to reciprocate. It is why we are encouraging exchanges between academic institutions within our military structures. And it is why we have conducted reciprocal ship visits and tours by senior officers. In the best case, engaging China's military will allow us to have a positive influence on this important player in Chinese politics, opening the way for Chinese cooperation on proliferation and regional security issues. At the very least, engagement between our two military establishments will improve our understanding of each other, thus lowering the chances for miscalculation and conflict.

What makes preventive defense work — whether it is in Russia, Europe, the Balkans, Latin America, or China — is American leadership. There is no other country in the world with the ability to reach out to so many corners of the globe. There is no other country in the world whose efforts to do so are so respected. At the same time, no one should think that preventive defense is a philanthropic venture — it is not. It's about hard work and ingenuity today, so that we don't have to expend blood and treasure tomorrow.

While preventive defense holds great promise for preventing conflict, we must appreciate that it is a strategy for influencing the world — not compelling it to our will. We must frankly and soberly acknowledge that preventive defense will not always work. That is why as Secretary of Defense, my top priority is still maintaining strong, ready forces and the will to use them to deter and defeat threats to our interests. We still maintain a smaller but still highly effective nuclear arsenal. We have a robust, threat-based, ballistic missile defense program. We maintain the best conventional forces in the world, many of which are forward-deployed in both Europe and the Asia-Pacific, and we continue to maximize our technological advantage over any potential foe, giving us dominance on any battlefield in the world. These forces and capabilities, coupled with the political will to use them, allow the United States to be very effective at deterring conflict around the world. These same capabilities and forces mean that if we cannot prevent or deter conflict, we can defeat aggression quickly and with a minimum of casualties.

The converse is also true. If we can prevent the conditions for conflict, we reduce the risk of having to send our forces into harm's way to deter or defeat aggression. The pivotal role of preventive defense, however, is not widely known to the public. Indeed, it is not well understood even by national security experts. The same was true, in fact, about the Marshall Plan in its early days. The Marshall Plan did not arise full grown like Venus from the shell. Indeed, George Marshall often maintained that when he gave his speech at Harvard in 1947, he did not present a "Marshall Plan." He said, instead, that it was a proposal, but he did not simply offer his proposal and go home. Marshall the statesman was a visionary man, but Marshall the soldier was also a practical man. As a practical man, he recognized that in a democracy, no national proposal, especially one involving US engagement in the world, becomes a reality unless you can win public support. The Marshall proposal became the Marshall Plan because George Marshall spent the next year going directly to the public and seeking its support.

Today, I am not issuing a proposal for preventive defense, but rather a report on how it is already shaping our world and the world of future generations in a positive way. But in order for preventive defense to succeed as an approach to national security, we, too, need to convince the American people. We need to convince America that at this pivotal point in history, as we seek to realize our fondest hopes for the revolutionary era in which we live, our engagement with the world and the programs supporting preventive defense are critical to our security. I have chosen the Kennedy School to present my thoughts on preventive defense because as scholars, the students and faculty here are uniquely equipped to understand what is at stake when we talk about preventive defense. As leaders and future policy makers, you are also uniquely equipped to explain the benefits of preventive defense to the American public and to take the concepts I have talked about today and expand upon them in your own careers. I urge you to do so.

Climate Change, U.S. Business, and The World Economy: The Need for Environmental Technologies

Keynote Address
John H. Gibbons
Department of State
June 18, 1996

In 1945, Secretary of State James F. Byrnes returned from the conference in San Francisco that set up the United Nations and stated that: "The battle of peace has to be fought on two fronts. The first is the security front where victory spells freedom from fear. The second is the economic and social front where victory means freedom from want. Only victory on both fronts can assure the world of an enduring peace."

Through the past nine Presidents and 22 Congresses, our primary emphasis has been the battle for global security, based on the uneasy politics of disarmament, nuclear deterrence and containment. During that time, the second front has grown continually in both size and complexity, shaped by the forces of globalization, technological advance, population growth, environmental degradation, and social change.

As the image of the Cold War recedes, it is the "second front" which advances. It is the plethora of human and environmental stresses which now commands our collective attention. It is the human wants — for jobs, education, health, a sound environment — and threats — infectious disease, illiteracy, mass migration, terrorism, and global change — which now define the second front of security policy.

In a recent speech at Stanford University, Secretary of State Warren Christopher again drew our attention to that broader concept of security — the "second front." He described how a lasting peace depends upon on our ability to deal effectively and equitably with the social, economic, and environmental needs of a growing global population while continuing to deter military threats.

Secretary Christopher articulated what many of us intuitively grasp. We face a set of regional and global challenges which transcend agency missions, disciplinary divides, and political boundaries. Our traditional notions of national security and the role of science and technology need to change. We must craft new policies and priorities which can both sustain our military deterrence capability and sustain environmentally-sound economic development. Last year, President Clinton took the first step in this direction by issuing the nation's first-ever National Security Science and Technology Strategy.

Our work increasingly involves building new linkages; sorting out the appropriate division of labor between the public and private sector, beginning new partnerships between old adversaries and forming new combinations of people, places, and ideas.

Global climate change is one of the new challenges we confront where we have made and continue to make tremendous gains in understanding. These gains in knowledge are significant in and of themselves: the business of science is the production and synthesis of new knowledge, and this process and its results are exciting in their own right to scientists. But the findings are significant in other ways as well, especially as they define future needs and future opportunities for society.

We have indeed learned a great deal about climate change since the phenomenon of CO_2 caused global warming was first elucidated in the late 1800's. Over the past decade, the world's governments have undertaken unprecedented assessment efforts to determine and describe the state of our understanding through the Intergovernmental Panel on Climate Change (IPCC), which has just released its Second Assessment Report. More than 2000 of the most prominent climate researchers from over 50 countries participated in this effort.

The bottom line is that there is — the revisionist few not withstanding — scientific consensus on the most salient issues.

We know that human activities are increasing the atmospheric concentrations of carbon dioxide and other greenhouse gases that affect atmospheric warming. Humans activities are also increasing the concentrations of sulfate aerosols that tend to the atmosphere by reflecting sunlight, but which also are the main component of acid rain, especially in the northern hemisphere. The atmospheric concentration of CO_2 has increased nearly 30% since the industrial revolution due to human activities. Methane has more than doubled. Nitrous oxide has gone up by 15 percent.

To put it plainly, we now know that the Earth's climate has changed in the past due to a variety of "natural" phenomena but that it is changing now in new and comparatively sudden ways. A few examples will illustrate this latter point:

- the global average surface temperature this century is as warm or warmer than any other century since at least 1400 AD;

- that temperature has increased by 0.3 to 0.6 C (about 0.5 to 1°F) over the last century;

- the last few decades have been the warmest this century;

- sea level has risen 10 to 25 cm (about 4 to 10 inches) over the last century; (thermal expansion)

- mountain glaciers have retreated worldwide this century;

- 1995 was the warmest year on record. Incidentally, the U.S. emissions of greenhouse gases currently account for about 16% of the world total, but the preponderance of emissions comes from rapidly growing developing countries.

The latest IPCC report contains a statement of particular significance:

> "The balance of evidence suggests that there is a discernible human influence on global climate." In other words, the "signal" of global warming is beginning to emerge from the "noise" of normal variability. The long atmospheric lifetime of many greenhouse gases, which is on the order of decades to many centuries, coupled with the centuries-long lag time for the oceans to equilibrate to temperature and CO_2 concentration change, means that the warming effect of anthropogenic emissions will be long-lived. Even after a hypothetical stabilization of the atmospheric concentrations of greenhouse gases, temperatures would continue to increase for several decades, and sea level would continue to rise for centuries. Reversing the effects therefore would also take centuries, and some impacts, such as species loss, are irreversible.

The broad outlines of a picture are beginning to emerge:

- Without specific policies that reduce the growth of greenhouse gas emissions, the Earth's average surface temperature is projected to increase by about 1 to 3.5 C (about 2 to 6.5 F) by 2100, a rate of warming that would apparently be greater than any comparable time interval over the last 10,000 years.

- Sea level is projected to rise by 15-95 cm (6-38 inches) by 2100.

- Increased evaporation in a warmer world will lead to increased precipitation worldwide that will be less evenly distributed in space and time. Changed patterns in precipitation will lead to more floods and droughts.

- Stabilization of the atmospheric concentration of CO_2, even at up to three times the pre-industrial concentration, would eventually require world-wide emissions of greenhouse gases to be cut below today's levels.

We know that climate change will be a significant new stress on ecological and social systems that are already affected by pollution, increasing resource extraction, massive population growth, and non-sustainable management practices. The effects will vary by region, and they may even be beneficial in some areas. Unfortunately, the mostly negative consequences of climate change are likely to affect the economy and the quality of life for this and future generations. Let me mention a few:

- Human Health will be adversely affected. There will be increases in the incidence of heat waves with high humidity like the episode in Chicago last year that resulted in several hundred deaths. Vector-borne diseases such as malaria, and non-vector-borne diseases such as cholera, are likely to spread as conditions for their survival change. To give just one example, we could face an additional 50 million cases per year of malaria near the end of the next century.

- Food Security will be threatened by changes in weather in some regions of the world, especially in the tropics and subtropics where many of the world's poorest people live.

- water Resources will be increasingly stressed, leading to substantial economic, social, and environmental costs, especially in regions that are already water-limited and where there is strong competition among users (we already know how contentious water rights are, even in parts of the U.S., and in other regions of the world, such as the Middle East).

- Human Habitat Loss will occur in regions where small islands and coastal plain and river areas are particularly vulnerable to sea level rise. For example Bangladesh is in danger of losing 17% of its land, while the combination of sea-level rise and storm surges could create 50 million environmental refugees in China.

- The composition, geographic distribution, and productivity of many ecosystems will shift as individual species respond to changes in climate. This may lead to loss of biological diversity and threaten the ability of ecosystems to provide the purification of air and water upon which we depend.

These are troubling and complex changes to confront, but fortunately, our research efforts have also shown us that there are a variety of approaches to adapt to and mitigate the impacts of climate change:

- IPCC points out that gains in energy efficiency of 10-30% above present levels are feasible at little or no net economic cost in many parts of the world through technical conservation measures and improved management practices over the next 2 to 3 decades. The efficiency of energy use, e.g., in the U.S. and Japan, has already increased by over 30% since 1975.

- Significant further reductions in greenhouse gas emissions can be economically achieved utilizing an extensive array of technologies, and policy measures that accelerate technology development, diffusion, and transfer in all sectors.

- Flexible, cost-effective, and internationally-coordinated policies can considerably reduce mitigation and adaptation costs.

Successful adaptation will depend upon education, technological advances, positive public policies, institutional arrangements, availability of financing, technology transfer, information exchange, and incorporation of climate change concerns into resource-use and development decisions. There are equity issues involved as well: Potential adaptation options for many developing countries are extremely limited by the availability of technological, economic, and societal capabilities.

Thus, the science of climate change gives us cause for both concern and hope. We do face a serious challenge, but we are not without tools. One of the most important tools we possess is environmental technology.

Environmental Technology

The global market for environmental goods and services is presently over $400 billion and growing. The current global market for energy efficiency is estimated at about $40 billion per year, even though efficient lighting is presently used in less than 1 percent of potential applications, and efficient motors and controls in less than 3 percent of installed applications. Projections by Royal Dutch Shell's forecasting group indicate that annual sales in renewable energy technologies alone could reach $50 billion by the year 2020 and almost $400 billion by 2040.

Besides technologies needed to address global environmental problems such as climate change and stratospheric ozone depletion, there are significant opportunities to address what some call "the brown agenda" — problems of pollution and environmental hazards in cities where more than 40 percent of the world population is concentrated. Presently, 90 percent of all sewage in the developing world is discharged directly into rivers, bays and the oceans. Indoor air pollution from burning of low-quality fuels in small stoves causes an estimated 4 million deaths annually among infants and children through acute respiratory illness.

Many of the technological solutions to these problems already exist. There is a growing demand for the engineering, managerial, and technical know-how which alone, or in combination with specific hardware, can be applied to local or regional environmental problems. For instance, with 70 percent of the freshwater resources worldwide being used for irrigation there is enormous opportunity for water-efficient irrigation approaches. The same is true for other solutions which combine both software and hardware, such as integrated pest management, efficient energy use, and environmental management systems. But a number of factors interfere with meeting this international need.

There is a funding gap for many environmental technologies: Innovations are often undercapitalized or countries lack the capital to purchase what they need. In Rio, in 1992, the UN Conference on Environment and Development estimated that more than $500 billion per year for the rest of the decade would be needed to achieve the goals set forth in Agenda 21. Much of this financial need is in the developing world. Even in the U.S. there is a significant shortage of venture capital for environmental technologies, partly due to uncertainties cause by the regulatory and permitting systems.

In addition, there is, in many paces, an ingenuity gap: Many countries facing severe environmental stresses do not have the knowledge infrastructure to assimilate and apply technologies, let alone develop their own. Sub-Saharan Africa has less than 45 scientists and engineers in research and development for each one million people, compared to more than 2900 for industrial nations. Transferring or developing environmentally-critical technologies in these areas will be extremely difficult, even if capital were made available and free markets function.

Finally, there is often an information gap: Even with good technologies, financing, know-how, and functioning markets, many technologies simply never get applied.

People are often unaware of opportunities and how to pursue them. The environmental technology industry is dominated by small and medium-sized businesses which frequently do not have the capacity to exploit overseas markets effectively. As former Ohio governor Richard Celeste once noted: "You can always buy something in English: you can't always sell something in English."

National Environmental Technology Strategy

Over the past two years, we have worked with many of you to define and implement a National Environmental Technology Strategy to support the development, domestic use, and export of environmental technologies by U.S. business. We met and brainstormed with over 10,000 people — from industry, academia, NGOs, and state and local governments — at more than 25 workshops across the country. We believe this strategy is unique; it was created with all the key stakeholders, and it capitalizes on the resources of more than a half-dozen federal agencies including EPA, DOE, Commerce, and Defense, and it includes public-private partnerships and an integrated set of policies which operate from the initial stages of R&D through commercialization and export promotion.

The strategy leverages important trends that are taking place in industry, where more and more companies pursue environmental excellence as a competitive strategy.

The strategy also looks beyond our borders and supports U.S. businesses seeking to capture rapidly expanding global markets for environmental technologies. We have:

- Developed an Environmental Technology Export Strategy to provide strategic market analyses of large emerging environmental technology markets and support U.S. businesses interested in moving into these markets.
- Developed an Initiative for Environmental Technologies (through USAID) to focus development assistance on critical environmental challenges in developing countries.
- Established a new Environmental Directorate at the Export-Import Bank to assist U.S. businesses with loans for environmental projects overseas. Funding for environmental projects at Ex-Im now exceeds $1 billion.
- Established the America's Desk (a State Department initiative) to help to solve problems for U.S. businesses overseas and bring business concerns to the forefront of the foreign policy process.

Budget Issues

Finally, I want to remind you that we have been fighting an uphill, and often counterproductive, battle with many in Congress over the role of government in supporting environmental technologies. Congress, despite industry support, reduced funding for the Environmental Technology Initiative (run by EPA) by over 80 percent in 1996, eliminating many programs designed to identify and reduce regulatory and other policy barriers to the development and use of innovative environmental technologies. Congress has recently cut development of renewable energy programs by 30 percent. Outyear funding cuts total almost 60 percent over the coming 7 years. Though there is broad recognition in both the public and private sector of the importance of institution and capacity building in foreign countries, AID's budget has been under continual attack and been cut to less than half the level of the mid 1980's. But AID is not alone. The impacts are deep and cut across almost all agencies.

Mind you, these Congressional cuts are being made to the President's budget which is certified to balance in 2002. It's not a matter of balancing the budget - it's a matter of conflicting priorities. The President's protection of these investments to build our future security is sound policy. Congress' less discriminating cutting is not. All this comes at a time when many of our competitors are increasing their investment in environmental technologies and their commitment to the environmental technology industry. Japan recently committed $430 million to develop and demonstrate their environmental technologies. In China alone Program funds are slated to increase $186 million next year. The Netherlands now has a $500 million program to support the development of more sustainable technologies. We face the reality of global competition.

The Clinton-Gore Administration does not intend to turn our backs on a $170 billion sector of the U.S. economy which represents 60,000 businesses and over one million high skilled and high paying jobs for Americans. Nor will we walk away from the opportunity to join forces with industry and other stakeholders to develop a new paradigm of environmental management. I hope that you will join with us to support our efforts to implement the National Environmental Technology Strategy; to foster productive public-private partnerships such as the Partnership for a New Generation of Vehicles; and, to develop a more robust science and technology for sustainable development. We owe it to ourselves, our neighbors, and our children!

The Environment on the Intelligence Agenda

John Deutch
Director of Central Intelligence (DCI)
Speech at the World Affairs Council in Los Angeles, California
July 25, 1996

The environment is an important part of the Intelligence Community agenda. Today I would like to explain what we mean by the term 'environmental intelligence,' why the Intelligence Community is involved in this work, and why our involvement is important for citizens of the United States and the world. I also want to demonstrate that environmental intelligence is not a new or expensive area of endeavor for the Intelligence Community.

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The Intelligence Community's job is to ensure that our senior policy makers and military commanders have objective information that will allow them to make better decisions. Through our collection and analytic effort, we compile intelligence reports that give our country's leadership insight into how events in all parts of the world will unfold and how these events will affect our national security.

Environmental trends, both natural and man-made, are among the underlying forces that affect a nation's economy, its social stability, its behavior in world markets, and its attitude toward neighbors.

I emphasize that environment is one factor. It would be foolish, for example, to attribute conflicts in Somalia, Ethiopia, or Haiti to environmental causes alone. It would be foolhardy, however, not to take into consideration that the land in each of these states is exploited in a manner that can no longer support growing populations.

Environmental degradation, encroaching deserts, erosion, and over farming destroy vast tracts of arable land. This forces people from their homes and creates tensions between ethnic and political groups as competition for scarce resources increases. There is an essential connection between environmental degradation, population growth, and poverty that regional analysts must take into account.

National reconnaissance systems that track the movement of tanks through the desert, can, at the same time, track the movement of the desert itself, see the sand closing in on formerly productive fields or hillsides laid bare by deforestation and erosion. Satellite systems allow us to quickly assess the magnitude and severity of damage. Adding this environmental dimension to traditional political, economic, and military analysis enhances our ability to alert policy makers to potential instability, conflict, or human disaster and to identify situations which may draw in American involvement.

Some events have already dictated that environmental issues be included in our intelligence agenda. When Moscow initially issued misleading information about the accident at the Chernobyl Nuclear Power Plant, U.S. leaders turned to the Intelligence Community to assess the damage and its impact on the former Soviet Union and neighboring countries.

During the Gulf War, when Saddam Hussein used ecological destruction as a weapon, policy makers and the military called on the Intelligence Community to track the movement of smoke from burning oil fields and the flow of oil released into the gulf. They asked whether damage to Iraq's Tuwaitha nuclear complex posed a danger to troops and local population.

In each of these cases, our answer to these questions was not and could not be, "the environment is not an intelligence issue." Our answers were classic intelligence: analysis based on our data from collection systems and open sources. We were able to assess the magnitude of the Chernobyl accident; we were able to tell U.S. troops how to avoid lethal hydrogen sulfide from oil fires; and we were able to tell military planners that damage to the reactor was not a threat.

I would like to emphasize that the environment is not a new issue for the Intelligence Community. For years we have devoted resources to understanding environmental issues. Much of the work that now falls under the environmental label used to be done under other names — geography, resource issues, or research.

For example, we have long used satellite imagery to estimate crop size in North Korea and elsewhere. This allowed us to forecast shortages that might lead to instability and to determine the amount of agricultural products a nation would need to import — information valuable to U.S. Department of Agriculture and to America's farmers. We have also tracked world availability of natural resources, such as oil, gas, and minerals.

We have for many years provided the military with information on terrain and local resources. As our forces embark on military, peacekeeping, and humanitarian operations in remote and unfamiliar territory, they will need even better information on environmental factors that could affect their health and safety and their ability to conduct operations.

Diplomacy will be ever more concerned with the global debate over environmental issues. As Secretary of State Christopher said in April, "our ability to advance our global interests is inextricably linked to how we manage the Earth's natural resources." He emphasized that we must put environment "in the mainstream of American foreign policy."

Intelligence has long supported diplomacy in this area, particularly in regard to key international environmental treaties and agreements. Here I would draw an analogy to the role of intelligence in negotiating the arms control treaties. Such treaties could not have been signed and ratified without intelligence to monitor compliance.

Likewise, the Intelligence Community monitors compliance with environmental treaties, such as the Montreal Protocol on Substances that Deplete the Stratospheric Ozone Layer and the London Convention that regulates the dumping at sea of radioactive and other wastes. Further, intelligence support should begin with the negotiation process, so that U.S. diplomats have the benefit of the best available information in framing effective and enforceable treaties in the future.

Environmental intelligence will also be a part of our support to economic policy makers. They need to know, for example, whether or not foreign competitors are gaining a competitive advantage over American business by ignoring environmental regulations. Intelligence can provide valuable information.

In short, the demand on the Intelligence Community for information on environmental issues will grow. As the world population expands and resources such as clean water and arable land become more scarce, it will become increasingly likely that activities of one country will have an environmental impact that goes beyond its borders. U.S. policy makers will need warning on issues that are likely to affect U.S. interests and regional stability.

Maintaining a capability for environmental intelligence will allow us to answer important questions that are likely to come from our consumers in the future. For example, China's rapidly growing population and booming economy will translate into a tremendous increase in demand for the world's natural resources, including oil and food. What impact will this have on world markets? As in the past, we must be prepared to answer such questions.

We should also be willing to provide data from our collection systems to help experts answer less traditional questions, for example: what impact will increased burning of fossil fuel have on the global environment?

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As I have mentioned, the Intelligence Community has unique assets, including satellites, sensors, and remote sensing expertise that can contribute a wealth of information on the environment to the scientific community. We also have mechanisms in place to share that information with outside experts. This effort will add significantly to our nation's capability to anticipate environmental crises.

In 1991, then-Senator Gore urged the Intelligence Community to create a task force to explore ways that intelligence assets could be tapped to support environmental research. That initiative led to a partnership between the Intelligence and scientific communities that has proven to be extraordinarily productive for both parties.

The Environmental Task Force found that data collected by the Intelligence Community from satellites and other means can fill critical information gaps for the environmental science community. Furthermore, these data can be handed over for study without revealing information about sources and methods.

For example, imagery from the earliest intelligence satellites — which were launched long before commercial systems — can show scientists how desert boundaries, vegetation, and polar ice have changed over time. These historical images, which have now been declassified, provide valuable indicators of regional and global climate change.

Some of the scientists who participated in the Environmental Task Force now make up a group called MEDEA. MEDEA works with the Intelligence Community to establish what we call the "Global Fiducials Program." Under this initiative, during the next decade we will periodically image selected sites of environmental significance. This will give scientists an ongoing record of changes in the earth that will improve their understanding of environmental processes. More importantly, it will greatly enhance their ability to provide strategic warning of potentially catastrophic threats to the health and welfare of our citizens.

At the same time, we do not see the Intelligence Community becoming a center of environmental science expertise or directly sponsoring research in that area. In this case, our job is to acquire the data and allow the scientific community to use them. Their work, quite properly, is sponsored by others, such as the National Science Foundation, the National Oceanic and Atmospheric Administration, National Aeronautics and Space Administration and academic institutions. We will continue to work with environmental experts to assure that their knowledge is brought to bear on what data we collect or retrieve from our considerable archives.

Our interaction with MEDEA is not only valuable for the environmental community, it also has had direct benefits for the Intelligence Community. MEDEA has worked closely with our analysts to develop techniques that have enhanced our ability to collect and interpret data from our collection systems.

Combining Intelligence Community data and expertise with knowledge from the scientific community can produce a better intelligence product for policy makers. Scientists from MEDEA worked with our analysts to respond to requests for information on environmental issues and problems — such as a series of oil spills in the Komi region of Russia. The Komi oil spill is just one example of how intelligence satellites and sensors can provide valuable information quickly after a natural or man-made disaster. In this case we could tell that large amounts of oil were not getting into the Arctic rivers.

In the United States, the Intelligence Community provides support to the Federal Emergency Management Agency and other civil agencies when there is a natural disaster. Using data from a variety of sources, within hours after a disaster strikes we can assess and report the nature and scope of the damage — conditions of roads, airports and hospitals; and the status of potential secondary threats such as dams and nuclear facilities. Here I would like to make two points:

- First, we only provide this support upon request. To image U.S. territory, we must first get permission.

- Second, we provide unclassified products generated from classified information. We have a Disaster Response Team that can quickly produce unclassified maps and diagrams that show the damage resulting from an earthquake, fire, flood, hurricane, oil spill, or volcanic eruption.

To give you a recent example of how well this system works, just a few weeks ago (June 5), the U.S. Forest Service requested our help in tracking the wildfires raging in Alaska. In this instance, they did not have enough planes to adequately chart the extent of the fires. Within 24 hours of the initial request, we delivered a map depicting the fire perimeter, smoldering fires, and the most intense blazes. This information was more comprehensive and detailed than data collected from overflights by civil aircraft and it was also available much more quickly than would have otherwise been possible.

We can also use our capabilities to provide warning before a disaster strikes. And we do share this information with foreign governments. For example, when a volcano on the Caribbean Island of Montserrat awakened in 1995, we monitored significant changes and alerted U.S. and British West Indies aid and military authorities so that they could prepare for a possible evacuation of the island's residents. Recently we noted a change within the volcano crater — a fissure had opened up, indicating that the risk of an eruption had increased dramatically. We quickly sent out a warning that allowed authorities on Montserrat to evacuate 4,000 people to a less dangerous area of the island.

These activities lie outside our traditional intelligence mission, but we believe it is important to provide aid when the capabilities would not otherwise be available. This effort costs us very little, and yields tremendous benefits to relief agencies, disaster victims, and potential victims whose lives could be saved by a timely warning.

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Vice President Gore has been a leader in advocating the use of intelligence information to improve environmental knowledge on an international level, for example to better monitor oil spills and chemical waste streams through international water ways.

The U.S.-Russian Joint Commission on Economic and Technological Cooperation — the Gore-Chernomyrdin Commission — has established a productive exchange of information between the U.S. and Russia.

This exchange has brought us unique and valuable data from Russia's intelligence programs. For example, the Russians have collected extensive data on the Arctic Ocean. This information is critical to our understanding of oceanographic and atmospheric processes, which are, in turn, critical to our ability to predict global climate change. Together with Russia, we have produced a CD-ROM atlas of the Arctic Ocean. It contains more than two million individual observations collected from 1948 to 1993 by Russian drifting stations, ice breakers, and airborne expeditions, as well as observations from U.S. buoys. This once-restricted data will now be available on the Internet through the World Wide Web and will more than double the scientific holdings of oceanographic data available to U.S. scientists.

The Arctic data are not only critical to scientific studies of climate change. They can also help us chart the movement of pollutants. The great rivers of Russia flow north into the Arctic. With them, they carry a heavy burden of waste from Russian industry, including chemicals, heavy metals, and organics, as well as radio-nuclides from Russia's defense programs. For example, 3 million curies of radioactive waste from Chelyabinsk , dumped into the Techa River years ago, have migrated to the Arctic Ocean, over 1,500 kilometers from the plant. Russian oceanographic data can help them and us to determine where radioactive materials and pollutants will travel once they reach the Arctic and whether they will affect U.S. and Canadian waters.

Early this year, Russia and the United States exchanged declassified imagery-derived diagrams of environmental damage over a 25-year period at Eglin Air Force Base in Florida and Yeysk Airbase in southwestern Russia. This ongoing exchange will help both countries clean up their toxic and radioactive sites. The techniques used to create these maps could help us identify potential sources of contamination in the future. Such information-sharing has proven a low-cost and highly effective way to build good will and strengthen international relationships. We should seek new opportunities to share information with other countries.

I would like to make one more key point about our work on environmental issues — the costs are small and the potential benefits enormous. The resources allocated to environmental intelligence are modest, perhaps one tenth of a percent of the intelligence budget for collection and analysis. We are using intelligence capabilities that are already in place. This important work requires no new capital investments.

Nor does environmental intelligence require us to divert collection systems from our priority targets or get involved in areas where we do not belong. The imaging of sites under the Global Fiducials program, for example, can be done during non-peak hours of satellite use. It will not interfere with collection against our highest priority targets, including the proliferation of weapons of mass destruction, terrorism, drug trafficking, and the activities of rogue states.

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In sum, the environment will continue to have an important place on the U.S. intelligence agenda.

- Environmental factors influence the internal and external political, economic, and military actions of nations important to our national security.

- Our intelligence customers, including the policy and military communities, need — and ask for — support on environmental issues and problems.

- The Intelligence Community has unique technical collection resources and analytic expertise that can fill critical information gaps for environmental scientists or help relief agencies cope with natural disasters.

- Through a productive partnership with the scientific community, we can provide strategic warning of environmental hazards that could endanger our health and welfare.

- These activities do not threaten our traditional missions.

- The vital work I have described requires only a modest commitment of resources.

I think it would be short-sighted for us to ignore environmental issues as we seek to understand and forecast developments in the post-Cold War world and identify threats to our national welfare. Just as Secretary Christopher promised "to put environmental issues in the mainstream of American Foreign policy," I intend to make sure that Environmental Intelligence remains in the mainstream of U.S. intelligence activities. Even in times of declining budgets we will support policy makers and the military as they address these important environmental issues.

International Environment

Address by
Eileen B. Claussen
Assistant Secretary of State
Oceans, International Environment, and Scientific Affairs
before the
26th Annual American Law Institute
American Bar Association
February 16, 1996
Washington, D.C.

Good morning. It is pleasure to have this chance to share some thoughts about international environmental issues with colleagues in the field of environmental law.

This conference comes at a critical point in the history of the environmental protection movement. After three decades of great progress in tackling our domestic environmental problems, the bipartisan coalition behind this movement seems to be unraveling. New voices are being heard saying that the environmental gains we have made are not worth the price, that environmental threats have been overblown and are "liberal claptrap", that enforcement is not a necessary part of an environmental regulatory regime.

Fortunately, it appears that these new voices have little resonance in the nation at large. To the contrary, it seems evident that the American public remains committed to the environment, perhaps more so now than ever before. And poll after poll makes clear that Americans want more environmental protection, not less, and they are willing to pay a price to get it.

This is particularly good news for those of us dealing with international environmental issues. In this area, the problems we face are getting worse, in some cases critically so.

The concentration of greenhouse gases in the atmosphere increases year by year, a trend that will accelerate as China and other developing countries industrialize. The destruction of forests and other habitat worldwide continues almost unabated, presaging what could be the greatest extinction of species since the demise of the dinosaurs. And remote areas like the Arctic are increasingly impacted by the global transport of persistent chemicals, such as DDT, that are still used in tropical regions of the world.

In the foreign affairs community, we are committed to dealing with these threats. Secretary Christopher in a recent speech at the Kennedy School highlighted the importance of environmental issues to our foreign policy. He emphasized that the Department of State would make environmental issues a priority and he pledged to fully integrate these concerns into our full range of diplomatic efforts.

This attention to international environmental problems recognizes the fact that these issues directly affect U.S. interests and the well-being of U.S. citizens. Depletion of the ozone layer is a good example. Completion of the Montreal Protocol agreement to phase out the use of ozone-depleting substances provides important health benefits to all Americans, reducing the risk of skin cancer and other health and environmental problems associated with increased ultraviolet radiation. This is particularly important given the troubling fact that skin cancer deaths in the United States have increased nearly 35% since 1973.

Global climate change may present an even greater direct threat to U.S. domestic interests. Sea level rise and the greater frequency of catastrophic weather events could exact a harsh toll on the U.S. economy. Even now some insurance companies are expressing concern over the potential costs of a global-warming induced increase in floods, hurricanes, and droughts, and they are reconsidering their rate structures for property insurance. Further, a general warming trend may lead to the spread of some now largely tropical diseases and to changes in agricultural patterns.

The loss of the planet's biological diversity is likewise of great concern to U.S. economic interests. U.S. farmers, for example, depend on wild strains of corn and wheat for efforts to breed in genetic traits like resistance to disease and insect pests. Should these wild strains become extinct, the U.S. food supply would be adversely affected. Equally important are the opportunity costs associated with the loss of biological sources for new drugs and other products that could improve humankind's quality of life. Access to these genetic resources is crucial to the American medical community.

We also face an emerging new threat from the use, primarily by non-OECD countries, of toxic chemicals and pesticides like DDT and PCBs that have long been banned in the U.S. and Western Europe. Because these substances are extremely persistent and are transported long distances through the air and water, they show up as residues far from their source. Data from the Arctic and the oceans shows that the concentration of these toxic chemicals in certain fish and marine mammals populations is increasing, posing concerns for human health and safety as well.

The foreign affairs community has also recognized the growing role environmental degradation plays in traditional national security interests. It seems that every year brings new evidence that environmental problems are key factors underlying many of the international conflicts and upheavals that affect U.S. security. Some examples:

- Population growth and destruction of the natural resource base in Haiti were root causes of that country's breakdown over the past decade.

- These same factors were important underpinnings of Somalia's disintegration into clan warfare, which likewise led to U.S. and international military involvement.

- Some of the most serious shortages of water — arguably mankind's most vital resource — are found in the Middle East. The progress that has been made thus far in promoting a lasting peace in the region could easily be jeopardized by a sudden conflict over scarce water reserves.

- Russia and the Newly Independent States may also experience destabilizing trends if health conditions continue to worsen as a result of the environmental abuses of the former Soviet regime.

As environmental issues have moved up the foreign policy agenda in response to these concerns, the international legal framework in this area has likewise evolved. Ten years ago there were only a few global environmental treaties in place, most of them on conservation issues. Now there are international regimes in force to deal with climate change, ozone layer depletion, hazardous wastes, Antarctica, biodiversity, and desertification. And multilateral negotiations will soon be underway on agreements to address new, emerging issues such as biosafety and the use of toxic chemicals, in particular those chemicals like DDT and PCBs that are persistent and that travel long distances through the atmosphere and oceans.

This framework of international environmental law has already produced some significant results. Depletion of the ozone layer is being slowed under the 1987 Montreal Protocol and its amendments. We are implementing a strong international regime to protect the environment of Antarctica. And an extensive set of agreements and action programs to protect the marine environment is being developed.

However, this emerging global framework may be undermined by several troubling trends. First, there is the danger that, in the effort to address important global threats, countries may give in to the pressure to adopt the outcome that has the greatest public appeal, rather than the one that makes the most environmental and economic sense. An example is that of the recent Basel Convention discussions where the Parties agreed to ban all exports of hazardous wastes from OECD to non-OECD countries, including wastes destined for recycling. The strong popular appeal of an outright ban appeared to outweigh the fact that ending the trade in wastes for recycling could increase the demand for virgin raw materials, a decidedly negative environmental impact. Nonetheless, despite the fact that the ban proposal could hinder the environmentally sound trade in scrap metal and scrap paper, most governments accepted the ban as a political expediency, hoping that they could fix the problem later by tightening the convention's definition of hazardous wastes to exclude these recyclable commodities. This tendency toward easy fixes to complex problems is not helpful and may end up undermining the credibility of our emerging environmental framework.

A second key trend is the reluctance of developing countries to take measures to address global environmental concerns because of perceptions that this will impede their short term economic growth. This is a vital issue because developing countries have a growing impact on the global environment. Most loss of biodiversity now takes place in developing countries and these nations' output of greenhouse gases, led by China's remarkable industrial growth, will soon exceed that of the industrialized world. It is thus important to find a new paradigm for cooperation between developed and developing countries—one that clearly links environmental protection and economic progress—if we are to make true, sustainable progress in addressing global threats.

Third, we are facing disturbing trends on compliance with international agreements. In the Montreal Protocol context, where developed countries have phased out CFCs, there is now a growing illegal trade in these ozone depleting chemicals. Developed countries have made commitments to seek to limit their year 2000 greenhouse gas emissions to 1990 levels, but it is clear that some have not really made a credible effort toward this goal and many who have made significant efforts, will still fall short. A sound global regime for environmental protection cannot be sustained if commitments are treated as little more than political promises.

Finally, there are the anti-environmental undercurrents in the domestic arena that have grave implications for our global efforts. The international environmental agenda is a particular target for an emerging ideology that seems to have a visceral problem with the concepts of multilateral cooperation and environmental protection. This is particularly troubling because the United States cannot protect its domestic and national security interests in the global environmental arena through unilateral actions; we need — even as a matter of self -interest — to cooperate and work with the rest of the world. Furthermore, U.S. withdrawal from international processes will exact a high economic cost. Already, we are not in a position to defend U.S. biotechnology interests in negotiations on a biosafety protocol under the biodiversity convention which we have not ratified, or to ensure the continuation of the environmentally sound trade in scrap metal and paper for recycling under the Basel convention, which we have also not ratified.

We cannot simply turn our back on these global threats and expect them to go away. Yet that is clearly what is implied by the effort to de-fund U.S. environmental protection programs, both domestic and international. Efforts to slash the U.S. global change research program are particularly symbolic of what appears to be a preference to remain ignorant of global environmental threats, rather than to better understand the nature of what could well become the gravest problem humankind has every faced. Because the United States is expected to be a world leader and to show others the way, it is critical that we remain firmly committed to sound, pragmatic efforts to protect the global environment and secure vital American interests.

The job for this year — and perhaps this decade — is to make a convincing case to the public that international solutions are necessary and desirable, and that our security cannot be protected without them. The existing framework of treaties and agreements keeps growing because the underlying problems continue to require internationally-accepted solutions. Every year brings a new dimension to this legal framework, as seen in the new negotiations that will begin this year on toxic chemicals and biosafety, new issues that can only be addressed through coordinated global actions.

What is clear is that the international environmental infrastructure we have today has already provided incalculable benefits to the United States and humankind (who can, after all, place a dollar value on the ozone layer?). We must continue to build on this infrastructure and to make continued progress in dealing with global environmental issues. To do less would be to deny ourselves the possibility of living in a cleaner, safer world.

The Environment and National Security

Remarks as prepared for delivery by
Sherri Wasserman Goodman
Deputy Under Secretary of Defense (Environmental Security)

National Defense University
August 8, 1996

Good morning. I am pleased to join you today to launch this discussion of the environment's key role in Secretary Perry's recent call for a revolution in security strategy. (Perry, Harvard, 1996) In his landmark speech at Harvard last May, the Secretary emphasized that our security depends on more than being able to guard against missile attacks. Our security depends equally as much on preventing the conditions that lead to conflict and on helping to create the conditions for peace. He calls this strategy "preventive defense." In Secretary Perry's words, with preventive defense we can "promote trust, stability, and democratic reform, and so help to prevent the conditions for conflict and build the conditions for peace." (Perry, Today, 1996) This morning I would like to give you my vision of environmental security as a key component of "preventive defense." First, I will discuss Secretary Perry's concept of "preventive defense." Second, I will review briefly the current knowledge about the relationship of the environment to national security. Third, I will present my thesis about the two ways in which environmental security supports preventative defense.

Fifty years ago, during an equally tumultuous time, our "preventive defense" posture in Europe — what became known as the Marshall Plan — recognized reconstruction of war-shattered economies as fundamental to peace and stability. Secretary Perry has stressed that today's "preventive defense" strategy — one that will support peace, making war less likely and deterrence unnecessary — must be based on three premises:

> "...first, that fewer weapons of mass destruction in fewer hands makes America and the world safer; second, that more democracy in more nations means less chance of conflict in the world; and third, that defense establishments have an important role to play in building democracy, trust, and understanding." (Perry, Harvard, 1996)

For "preventive defense" to succeed we must address the increasingly diverse threats to our security in the post-Cold War world. President Clinton in his 1996 State of the Union Address described these threats in his call to maintain America's leadership in the world:

> "The threats we face today as Americans respect no nation's borders. Think of them: terrorism, the spread of weapons of mass destruction, organized crime, drug trafficking, ethnic and religious hatred, aggression by rogue states, environmental degradation." (Clinton, 1996)

As the President recognized, the underlying causes of conflict and instability, such as ethnic cleavages and environmental degradation, may threaten our national interests in regions of strategic importance. Understanding the causes of conflict and instability, providing adequate warning of potential crises, and acting well before a crisis to avoid costly military interventions are at the heart of "preventive defense." Operationalizing "preventive defense" will pose what I believe is a primary challenge to policy makers in the years ahead.

Policy makers are beginning to delve more deeply into the causes and consequences of conflict and instability in the post-Cold War world. It is increasingly clear that environmental degradation and scarcity play a key role in this complex equation. In 1996, for the first time, the National Security Strategy (NSS) recognizes that "a number of transitional problems which once seemed quite distant, like environmental degradation, natural resource depletion, rapid population growth and refugee flows, now pose threats to our prosperity and have security implications for both present and long-term American policy." (NSS, 1996) Secretary Christopher, in a major speech in April at Stanford, stressed that "addressing natural resource issues is frequently critical to achieving political and economic stability, and to pursuing U.S. strategic goals around the world." (Christopher, Stanford, 1996) Indeed, Secretary Christopher has embarked on an effort to fully engage the State Department in the environmental aspects of foreign policy. And, as you all know, Vice President Gore has been a tireless champion of the environment. For example, his recent work on the cooperative effort he chairs with the Russian Prime Minister, known as the Gore-Chernomyrdin Commission, has been based in part on his recognition that underlying environmental problems are linked directly to the future stability and security of Russia.

The role of environmental degradation and scarcity in causing instability and conflict is the subject of much debate in the academic community, as you will hear about later this morning. Despite the lack of academic consensus, it is clear that environmental degradation and scarcity and related conditions (such as increased population growth, urbanization, and migration, and the spread of infectious diseases) may contribute significantly to instability around the world.

Scarcity of renewable resources such as water, forests, cropland, and fish stocks occur from degradation and depletion of resources, over consumption and overuse of resources, and/or inequitable distribution of resources. Often these causes of scarcity combine to exacerbate the scarcity's impact.

Environmental scarcities can interact with political, economic, social, and cultural factors to cause instability and conflict. Particularly in poorer countries, scarcities can limit economic options and therefore force those already impoverished to seek their livelihood in ecologically endangered areas such as cities. The "megacities" of the South are especially vulnerable. The developing world's urban population is expected to increase from 1 billion in 1985 to 4 billion — or almost half of the world's population — by 2025. (NSSTS, 1996) Such areas can become teeming areas for disease, crime, and social decay. The multiple effects of environmental scarcity, including large population movements, economic decline, and capture of environmental resources by elites, can weaken the government's capacity to address the demands of its citizens. If the state's legitimacy and capacity for coercive force are undermined, the conditions are ripe for instability and violent conflict. If the state's legitimacy and coercive force capacity remain intact or are bolstered, the regime may turn more authoritarian and challenge the trend of democracy and free markets around the world. Either way, our security is affected, and U.S. military forces may become involved, when environmentally linked instability spills over to other states in a key region, or when a complex humanitarian emergency results from environmentally rooted population movements.

For example, in Haiti, environmental conditions, such as deforestation, soil erosion, and water pollution, along with demographic, socioeconomic, and political problems including poverty, urban overpopulation, and a highly centralized government combined to create the societal decay that led to the involvement of American troops. Haiti's deforestation is its most severe environmental concern, one that world relief agencies have explicitly tied to the country's refugee crisis which brought in American troops. One need only look at satellite photos of Haiti and its island neighbor, the Dominican Republic: on the Dominican side lie vast, forested areas; on the Haiti side, the land has been stripped bare by rampant clear-cutting. The disappearance of Haiti's forests and its consequent soil erosion are so extreme that coral reefs have been damaged, resulting in devastating reductions in fish stock. Economic deprivation has driven people from their land, which in turn has deepened the country's political crisis and intensified the outpouring of people seeking refuge in the United States. An environmental crisis similar to Haiti's thus may have significant regional or even international effects, which, in combination with other factors, could compel U.S. military involvement.

Even where environmental degradation or scarcity is not likely to be a cause of instability or conflict, military environmental cooperation can help promote democracy trust, and capability to address environmental problems. In this context, defense environmental cooperation supports one of Secretary Perry's three premises of preventive defense: that "defense establishments have an important role to play in building democracy, trust and understanding."

I believe our environmental security challenge now under "preventive defense" is twofold. One challenge is to understand where and under what circumstances environmental degradation and scarcity may contribute to instability and conflict, and to address those conditions early enough to make a difference. The second challenge is to determine where military environmental cooperation can contribute significantly to building democracy, trust and understanding. These two elements together constitute the environmental security pillar of "preventive defense."

We must begin these efforts now. As the National Security Strategy observes, our current decisions regarding the environment and natural resources will affect the magnitude of the security risks we face over the next generation. (NSS, 1996)

The first need under the environmental security pillar of "preventive defense" is adequate indications and warnings of potential crises. The Intelligence Community has begun to take a leading role in this important area. Last year DoD co-sponsored a conference with the Intelligence Community on environmental security, and national security. The conference participants concluded that the Intelligence Community has the information-gathering infrastructure and the ability to perform integrated analysis on linkages between environmental problems and other instability factors necessary to contribute to an indications and warning system. (Environmental Security/National Security Conference Findings, 1995) In his speech to the World Affairs Council in Los Angeles two weeks ago, the Director of Central Intelligence, John Deutch, emphasized the importance of the environment in the Intelligence Community's priorities:

> "There is an essential connection between environmental degradation, population growth, and poverty that regional analysts must take into account. National reconnaissance systems that track the movement of tanks through the desert, can, at the same time, track the movement of the desert itself, see the sand closing in on formerly productive fields or hillsides laid bare by deforestation and erosion. Satellite systems allow us to quickly assess the magnitude and severity of damage. Adding this environmental dimension to traditional political, economic, and military analysis enhances our ability to alert policy makers to potential instability, conflict, or human disaster and to identify situations which may draw in American involvement." (Deutch, Los Angeles, 1996)

As long ago as 1991 then-Senator Gore urged the Intelligence Community to create a task force to determine ways that intelligence assets could be tapped to support environmental research. The Environmental Task Force Gore helped create found that data collected by the Intelligence Community from satellites and other means can fill important information gaps for the environmental science community. (Deutch, Los Angeles, 1996) Examples of the specific products the Intelligence Community can produce for environmental purposes are maps depicting environmental contamination at Eglin Air Force Base in Florida and Yeysk Airbase in Russia that Vice President Gore and Russian Prime Minister Chernomyrdin exchanged in January 1996 at a meeting of the Gore-Chernomyrdin Commission. These maps were prepared exclusively from classified assets. We hope to continue this cooperation and develop our respective capabilities previously used exclusively for intelligence purposes to support creation of warning mechanisms for potential crises.

In a speech on the Senate floor on June 28, 1990, Senator Sam Nunn spoke of the need to "harness some of the resources of the defense establishment ... to confront the massive environmental problems facing our nation and the world today." (SERDP, 1994) That led to the establishment of the multi-agency Strategic Environmental Research and Development Program (SERDP), which plays an important role in developing and analyzing the data needed for alerting us to possible security threats. Through SERDP, which was established in 1990, Senator Nunn and then-Senator Gore had the foresight to recognize that the U.S. defense posture had to be adjusted to meet the challenges of the post-Cold War world, challenges that include environmental degradation. SERDP has made significant contributions to our understanding of global environmental trends, with key projects including the Joint DoD/Energy Department Atmospheric Remote Sensing and Assessment Program, which monitors ozone levels; and the Acoustic Monitoring of the Global Ocean Climate, which measures global ocean temperature and incorporates these data into climate change models. This analysis is important to developing the types of warning systems I believe we need.

Military operators are also paying more attention to how we can be alert to potential crises. We were certainly surprised that Canada and Spain — two NATO allies — would nearly come to blows over fishing rights. This dispute, which happened just off the U.S. coast, proved that even among developed countries, there is the potential for fierce resource competition. This incident was a real wake up call to our military operators, who reviewed the origins of the dispute carefully and are now seeking to work with other organizations in improving international fisheries management.

We have also begun looking at assessment and warning mechanisms with our NATO partners. "Environment and Security in an International Context," a new pilot study launched by NATO's Committee on the Challenges of Modem Society this past March, calls for the NATO representatives to work closely with representatives of the North Atlantic Cooperation Council and the Partnership for Peace countries. During the course of the study we will identify and assess security risks posed by environmental problems, prioritize those risks for action, and devise a action plan to address them — with a strong emphasis on preventive actions. (NATO/CCMS Pilot Study, 1996)

Promoting military environmental cooperation that contributes significantly to democracy, trust and understanding is the second element of the environmental security pillar of "preventive defense." Secretary Perry himself has acknowledged the unprecedented opportunity the Defense Department has today to establish and reinforce key relationships:

> "Our environmental efforts are also having a global impact. All over the world, American forces are sharing the wealth of their environmental experience with foreign militaries, showing them by example and instruction how to protect and preserve the air, lands, and waters in their own countries. This is one of many forms of military-to-military engagements our forces are conducting to help America build cooperative relations with new friends and former foes." (Perry, Today, 1996)

In the last few years, the Defense Department has established a number of defense environmental relationships that fulfill Secretary Perry's premise that "defense establishments have an important role to play in building democracy, trust and understanding." Perhaps the most significant is our defense environmental relationship with Russia, a key nuclear power in the post-Cold War world. We have both a bilateral relationship, and a trilateral arrangement with Norway, focused on the environmental security of the fragile and militarily active Arctic region. This environmental trilateral, called the Arctic Military Environmental Cooperation (AMEC), is a promising effort begun in 1994 by Secretary Perry and Norwegian Defense Minister Kosmo with the express purpose of promoting military environmental cooperation. Russia, Norway and the U.S., through AMEC, have already evaluated specific projects to reduce environmental degradation in the Arctic caused by defense activities. Marking the importance of the bilateral defense environmental relationship, Secretary Perry signed a separate Memorandum between the U.S. Department of Defense and the Ministry of Defense of the Russian Federation on Cooperation in Environmental Protection Issues with the Russian Minister of Defense in 1995. The U.S. and Russia are utilizing the MOU's information exchange mechanisms as the beginning of a new bilateral environmental relationship. In late

October, I will be leading a delegation to Russia to exchange experiences in environmental education and training. Another promising initiative launched under the MOU is Russia's development of derived products on the Johnston Atoll, where the U.S. has a plant that destroys chemical weapons.

At the end of the Cold War our European Command (EUCOM) initiated a military-to-military program in Central and Eastern Europe to encourage and facilitate the democratization process. Early in that program the environment emerged as an important area for cooperation as the militaries of these countries became aware of and sought to address their environmental responsibilities. Since the beginning of this "mil-to-mil" program we have engaged multiple federal agencies, state and local governments, non-governmental organizations, the public, and the military in programs geared toward meeting environmental challenges. We have shown our Central and Eastern European partners, through working with representatives of a wide array of organizations, that the military can and should participate easily and effectively in open and cooperative processes within a democratic framework.

We are also using environmental topics within NATO to promote democracy and build free markets. Last year we hosted an environmental conference in Germany for all the NATO, North Atlantic Cooperation Council, and Partnership for Peace nations, a gathering which includes both military and civilian delegates as well as representatives of the American environmental private sector. Partnership for Peace countries are now participating in all of the major NATO environmental projects. Environmental cooperation helps NATO and Partnership for Peace countries learn about each others' capabilities, thus facilitating the process of bringing new members into the NATO alliance.

Given Russia's strategic importance to the NATO organization, we are continuing our continuous line of effective cooperation with the Russians under the NATO rubric. Our activities are geared towards furthering Secretary Perry's six postulates for NATO. Next month, several NATO countries hope to meet with Russian defense representatives to discuss the 16 plus 1 initiative on environmental cooperation. The 16 plus 1 initiative process brings the sixteen full members of NATO together with Russia to explore areas for potential cooperation. Emergency preparedness was the first issue addressed under this umbrella. As the second area of cooperation between NATO and Russia under the 16 plus 1 imitative, environmental cooperation has a significant role in promoting trust and understanding between NATO and Russia at this crucial time.

Cooperation with other key U.S. Government agencies is important to designing the most effective forms of environmental cooperation. Recognizing that the whole is often greater than the sum of its parts, on July 3, 1996, Secretary Perry, Secretary O'Leary, and Administrator Browner signed a Memorandum of Understanding calling for cooperation among DoD, the Energy Department, EPA, to jointly address critical environmental concerns. (MOU, 1996) Cooperative activities under the MOU will focus on enhancing other nations' abilities to identify and manage environmental threats, as well as on addressing the environmental consequences of both the military and civilian Cold War defense activities, and on strengthening ties with developing and democratizing nations. Methods of cooperation will include information exchange, research and development, monitoring, risk assessment, technology demonstration and transfer, emergency response training, regulatory reform, and environmental management. We plan to engage the other key U.S. Government departments and agencies in our MOU activities. In fact, we already are: last week, at DoD's invitation, we hosted a Polish delegation from the Ministries of Defense and Environment to develop bilateral, multi-agency environmental cooperation involving the Environmental Protection Agency and Departments of State, Energy, and Commerce. By the end of the week, the Polish delegation had proposed five areas for defense environmental cooperation, the heart of which is making American environmental technology and services available to assist Polish environmental problems, both in the military and the commercial sector.

We are also seeking to transfer our successful European cooperation model to the Asia Pacific region. We have invited representatives from the Environmental and Defense ministries of nearly 50 nations to an Asia-Pacific Defense Environmental Conference to be held in Hawaii next month. The purpose of the conference is to establish a defense environmental foundation for the region and to use environmental cooperation to strengthen the military-to-military relationships among the three co-sponsoring nations — Canada, Australia, and the U.S. — and the invited nations. The conference will emphasize basic principles such as cooperation with civilian authorities, non-governmental organizations and the public, and partnerships with the private sector. We have carefully crafted our invitations to these conferences to include representatives from both defense and environmental agencies to promote a constructive relationship between the military and civilian entities.

We are now also embarking on environmental security cooperation with SOUTHCOM. In fact, the new SOUTHCOM commander himself, General Wes Clark, recently expressed his personal interest in such cooperation to me. Through military environmental cooperation, he will be able to build bridges to our neighbors in Central and South America that will help to strengthen the new democracies in many of these countries. Indeed, when I told him I thought we could kick off this cooperative effort in 12-18 months, after laying the appropriate groundwork and organizing a conference among nations in South and Central America, his response was "Can't we do this sooner!"

To summarize, you've heard me discuss 1) the concept of "preventive defense," 2) how the environment and security are linked, and 3) my vision of the environment's role in "preventive defense." This vision has two parts: first, obtaining adequate indications and warnings of potential crises; and two, using defense environmental cooperation to build democracy, trust and understanding. In conclusion, I would like to talk briefly about what you, the members of our military academic community, can do to support us in our initiatives. "Preventive defense" calls for a variety of tools to create the conditions for peace and cooperation. These include educating both U.S. and foreign officers to understand the causes and consequences of conflict and the requirements for peace; educating foreign officers at our military staff and command colleges to learn how to operate in a democratic society under civilian control; and sending teams of U.S. military officers and civilians to help nations build modern professional defense establishments capable of cooperating effectively with civilian authorities. (NSSTS, 1995) My message to you is that environmental security concerns must be an important part of this education and training process. Some of you have already integrated environmental security issues into your curricula and research; some of you may be contemplating just how to incorporate these issues into your programs; others may still be skeptical that environmental problems can actually pose threats to our security, although I expect I've gone some ways toward making that case this morning. Even if you do not accept that premise, it is now indisputable that defense environmental cooperation can help build trust, understanding and capability to address environmental challenges. I hope that over the next day and a half you will share your course outlines and your ideas, your research plans and your objectives, your publications and your needs. I am pleased to be working with you during this time to determine how you can best aid us in our efforts, and I look forward to a long and fruitful collaboration with you. After all, educating the new generation of military officers to understand and address environmental threats to our security is critical to the ultimate success of "preventive defense." The President said it best in his State of the Union Address in January: "If we fail to address these threats today, we will suffer the consequences in all our tomorrows." (Clinton, 1996)

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Excerpts from A National Security Strategy of Engagement and Enlargement

The White House
February 1996

I. Introduction

The President developed a Climate Change Action Plan to help reduce greenhouse emissions at home and launched the U.S. Initiative on Joint Implementation to help reduce emissions abroad. The United States also takes a leading role at the international level in phasing out ozone-depleting substances.

In June 1993, the U.S. signed the Biodiversity Treaty and one year later, the Desertification Convention. With strong U.S. leadership, the United Nations successfully concluded negotiations on a multilateral agreement designed to reverse the global trend of declining fish stocks. The agreement complements the UN Law of the Sea Convention, giving direction to countries for implementing their obligation under the Convention to cooperate in conserving and managing straddling and highly migratory fish stocks.

The Administration has asserted world leadership on population issues. We played a key role during the Cairo Conference on Population and Development in developing a consensus Program of Action, including increased availability of voluntary family planning and reproductive health services, sustainable economic development, strengthening of family ties, the empowerment of women including enhanced educational opportunities and a reduction in infant and child mortality through immunizations and other programs.

II. Advancing our Interests Through Engagement and Enlargement

National Security Emergency Preparedness

We will do all we can to prevent destructive forces such as terrorism, the proliferation of weapons of mass destruction, threats to our information systems and catastrophes from within such as natural disasters, from endangering our citizens. But we must also be prepared to respond effectively if an emergency does occur in order to ensure the survivability of our institutions and national infrastructure, protect lives and property and preserve our way of life. National security emergency preparedness is imperative, and we must continue to work aggressively to ensure appropriate threat mitigation and response capabilities, including the ability to restore to normalcy elements of our society affected by national security emergencies or disasters resulting in widespread disruption, destruction, injury or death. To this end, comprehensive, all-hazard emergency preparedness planning by all Federal departments and agencies continues to be a crucial national security requirement.

The Environment and Sustainable Development

The more clearly we understand the complex interrelationships between the different parts of our world's environment, the better we can understand the regional and even global consequences of local changes to the environment. Increasing competition for the dwindling reserves of uncontaminated air, arable land, fisheries and other food sources and water, once considered 'free' goods, is already a very real risk to regional stability around the world. The range of environmental risks serious enough to jeopardize international stability extends to massive population flight from man-made or natural catastrophes, such as Chernobyl or the East African drought, and to large-scale ecosystem damage caused by industrial pollution, deforestation, loss of biodiversity, ozone depletion, desertification, ocean pollution and, ultimately, climate change. Strategies dealing with environmental issues of this magnitude will require partnerships between governments and non-governmental organizations, cooperation between nations and regions, sustained scientific research and a commitment to a strategically focused, long-term policy for emerging environmental risks.

The decisions we make today regarding military force structures typically influence our ability to respond to threats 20 to 30 years in the future. Similarly, our current decisions regarding the environment and natural resources will affect the magnitude of their security risks over at least a comparable period of time, if not longer. The measure of our difficulties in the future will be settled by the steps we take in the present.

As a priority initiative, the U.S. successfully led efforts at the Cairo Conference to develop a consensus Program of Action to address the continuous climb in global population, including increased availability of family planning and reproductive health services, sustainable economic development, the empowerment of women to include enhanced educational opportunities and a reduction in infant and child mortality. Rapid population growth in the developing world and unsustainable consumption patterns in industrialized nations are the root of both present and potentially even greater forms of environmental degradation and resource depletion. A conservative estimate of the globe's population projects 8.5 billion people on the planet by the year 2025. Even when making the most generous allowances for advances in science and technology, one cannot help but conclude that population growth and environmental pressures will feed into immense social unrest and make the world substantially more vulnerable to serious international frictions.

Providing for Energy Security

The United States depends on oil for more than 40% of its primary energy needs. Roughly half of our oil needs are met with imports, and a large share of these imports come[s] from the Persian Gulf area. The experiences of the two oil shocks and the Gulf War show that an interruption of oil supplies can have a significant impact on the economies of the United States and its allies. Appropriate economic responses can substantially mitigate the balance of payments and inflationary impacts of an oil shock; appropriate security policy responses to events such as Iraq's invasion of Kuwait can limit the magnitude of the crisis.

Over the longer term, the United States' dependence on access to foreign oil sources will be increasingly important as our resources are depleted. The U.S. economy has grown roughly 75% since the first oil shock; yet during that time our oil consumption has remained virtually stable and oil production has declined. High oil prices did not generate enough new oil exploration and discovery to sustain production levels from our depleted resource base. These facts show the need for continued and extended reliance on energy efficiency and conservation and development of alternative energy sources. Conservation measures notwithstanding, the United States has a vital interest in unrestricted access to this critical resource.

Promoting Sustainable Development Abroad

Broad-based economic development not only improves the prospects for democratic development in developing countries but also expands the demands for U.S. exports. Economic growth abroad can alleviate pressure on the global environment, reduce the attraction of illegal narcotics trade and improve the health and economic productivity of global populations.

The environmental consequences of ill-designed economic growth are clear. Environmental damage will ultimately block economic growth. Rapid urbanization is outstripping the ability of nations to provide jobs, education and other services to new citizens.

The continuing poverty of a quarter of the world's people leads to hunger, malnutrition, economic migration and political unrest. Widespread illiteracy and lack of technical skills hinder employment opportunities and drive entire populations to support themselves on increasingly fragile and damaged resource bases. New diseases, such as AIDS, and other epidemics which can be spread through environmental degradation, threaten to overwhelm the health facilities of developing countries, disrupt societies and stop economic growth. Developing countries must address these realities with national sustainable development policies that offer viable alternatives. U.S. leadership is of the essence to facilitate that process. If such alternatives are not developed, the consequences for the planet's future will be grave indeed.

Domestically, the United States is working hard to halt local and cross-border environmental degradation. In addition, the United States is fostering environmental technology that targets pollution prevention, control and cleanup. Companies that invest in energy efficiency, clean manufacturing and environmental services today will create the high-quality, high-wage jobs of tomorrow. By providing access to these types of technologies, our exports can also provide the means for other nations to achieve environmentally sustainable economic growth. At the same time, we are taking ambitious steps at home to better manage our natural resources and reduce energy and other consumption, decrease waste generation and increase our recycling efforts.

Internationally, the Administration's foreign assistance program focuses on four key elements of sustainable development: broad-based economic growth; the environment; population and health; and democracy. We will continue to advocate environmentally sound private investment and responsible approaches by international lenders. As mentioned above, the Multilateral Development Banks (MDBs) are now placing increased emphasis upon sustainable development in their funding decisions, to include a commitment to perform environmental assessments on projects for both internal and public scrutiny. In particular, the Global Environmental Facility (GEF), established in 1994, provides a source of financial assistance to the developing world for climate change, biodiversity and oceans initiatives that will benefit all the world's citizens, including Americans.

The U.S. is taking specific steps in all of these areas:

- In June 1993, the United States signed the Convention on Biological Diversity, which aims to protect and utilize the world's genetic inheritance. The Interior Department created a National Biological Service to help protect species and to help the agricultural and biotechnical industries identify new sources of food, fiber and medications.

- New policies are being implemented to ensure the sustainable management of U.S. forests by the year 2000, as pledged internationally. In addition, U.S. bilateral forest assistance programs are being expanded, and the United States is promoting sustainable management of tropical forests.

- In the wake of the 1992 United Nations Conference on Environment and Development, the United States has undertaken initiatives to reduce land-based sources of marine pollution, maintain populations of marine species at healthy and productive levels and protect endangered marine mammals and coral reefs.

- The United States has focused technical assistance and encouraged non-governmental environmental groups to provide expertise to the new independent states of the former Soviet Union and Central and Eastern European nations that have suffered the most acute environmental crises. The Agency for International Development, the Environmental Protection Agency and other U.S. agencies are engaged in technical cooperation with many countries around the world to advance these goals. The United States has also been working bilaterally with a number of developing countries to promote their sustainable development and to work jointly on global environmental issues.

- The Administration is leading a renewed global effort to address population problems and promote international consensus for stabilizing world population growth. Our comprehensive approach stresses family planning and reproductive health care, maternal and child health, education and improving the status of women. The 1994 International Conference on Population and Development held in Cairo, endorsed these approaches as important strategies in achieving our global population goals. At the 1995 UN Conference on Women in Beijing, the United States promoted women's — and children's — international rights.

- With regard to the United Nations, the G-7 leaders at the Halifax Summit in 1995 endorsed an ambitious effort to modernize the organization's economic and social functions through better coordination, consolidation of related agencies, rethinking agency mandates and creating an effective management culture in a smaller and more focused Secretariat. Following President Clinton's call for a UN reform commission, the UN General Assembly established the High Level Working Group on Strengthening the UN System in September 1995.

- In April 1993, President Clinton pledged that the United States would reduce our greenhouse gas emissions to 1990 levels by the year 2000, in accordance with the Framework Convention on Climate Change. In March 1995, we and other parties to the Convention agreed to negotiate steps to be taken beyond the year 2000. We are resolved to deal forcefully with this threat to our planet while preserving U.S. economic competitiveness.

- The United States and other countries have agreed to protect the ozone layer by phasing out use of the major ozone-depleting substances. In 1995, we also agreed with other nations to decrease use of additional ozone-depleting chemicals.

Memorandum of Understanding

Among
The Environmental Protection Agency
The Department of Energy
and
The Department of Defense
Concerning Cooperation in Environmental Security

July 3, 1996

The Environmental Protection Agency, the Department of Energy, and the Department of Defense (the Parties),

Recognizing that America's national interests are inextricably linked with the quality of the earth's environment, and that threats to environmental quality affect broad national economic and security interests, as well as the health and well-being of individual citizens;

Recognizing that environmental security, including considerations of energy production, supply and use, is an integral component of United States national security policy and that strong environmental security contributes to sustainable development;

Recognizing that environmental degradation can have global consequences that threaten the environment, health and safety in the United States;

Recognizing the central role of science and technology in promoting sustainable development and in responding to global threats to environmental security;

Recognizing the need to overcome the environmental legacy of the Cold War in order to promote prosperity and stability;

Recognizing that the Secretary of State has primary responsibility for the conduct of United States foreign policy;

Recognizing that each of the Parties has a different experience, expertise, and perspective and that their collaboration can uniquely assist in addressing international problems of importance for environmental security and can serve as a model for other countries;

Recognizing that each of the Parties has an important role to play in demonstrating and promoting approaches and technologies that achieve safe and effective environmental management in defense-related activities in the United States and abroad;

Recognizing that the Parties have established cooperation with the private and public sectors as a basis for jointly addressing sustainable development and environmental security; and

Believing that enhanced cooperation on international environmental protection issues that is consistent with United States foreign policy and national security objectives is of mutual benefit,

Have agreed as follows:

I. Purpose

1. The purpose of this Memorandum is to establish a framework for cooperation among the Parties to strengthen coordination of efforts to enhance the environmental security of the United States, recognizing the linkage of environmental and national security matters.

   The parties do not intend this Memorandum to create binding legal obligations.

II. Scope

1. The Parties shall develop and conduct cooperative activities relating to the international aspects of environmental security, consistent with United States foreign policy and their individual mission responsibilities, utilizing their legal authorities and facilities appropriate to specific tasks directed at achieving mutually agreed upon goals.
2. Cooperative activities under this Memorandum may be conducted in areas contributing to improved environmental security, where such cooperation contributes to the efficiency, productivity, and overall success of the activity. Such activities include: information exchange, research and development, monitoring, risk assessment, technology demonstration and transfer, training, emergency response, pollution prevention and remediation, technical cooperation, and other activities concerned with radioactive and non-radioactive contamination and other adverse environmental impacts on terrestrial areas, the atmosphere, hydrosphere, cryosphere, the biosphere (including human health) and the global climate system; defense or defense (strategic industrial activities, energy production, supply and use, and related waste management); or other such matters as the Parties may agree upon, according to criteria to be mutually developed by the Parties.
3. The forms of cooperation under this Memorandum may consist of the following: participation in joint projects addressing the activities cited in paragraph 2 above, including sharing of technical expertise; cooperative work to institute and enhance environmental management systems related to defense activities; information management and exchange; participation in relevant symposia, conferences and seminars; development of joint scientific and policy publications; provision of equipment and associated materials to foreign entities through the appropriate instrument, consistent with United States law; temporary assignments of personnel from one Party to another; and such other forms of cooperation as the Parties may agree upon.
4. Each Party may use the services of and enter into agreements with appropriate institutions, such as universities and governmental and non-governmental organizations, to develop and conduct activities under this Memorandum, consistent with

applicable law. Where required by law, applicable regulations or procedures, such agreements shall be subject to consultation with and the concurrence of the Department of State.

III. Funding

1. Unless otherwise agreed, each Party shall provide the resources for its participation in activities under this Memorandum. The ability of each Party to carry out activities under the Memorandum shall be subject to the availability of appropriated funds, personnel, and other resources.
2. The details of any interagency transfer of funds will be set forth in specific interagency agreements. This Memorandum shall not be used to obligate or commit funds or as the basis for the transfer of funds between or among the Parties.

IV. Management

1. Activities undertaken under this Memorandum will be consistent with applicable authorities and, where required, in consultation with and/or concurrence of the Department of State.
2. Each Party shall designate in writing a Program Coordinator and a Deputy to manage activities under this Memorandum. Each Party may designate a replacement Program Coordinator or Deputy at any time upon written notice to the other Parties. The Program Coordinators shall meet at least semi-annually, and at other occasions as deemed necessary and at the request of any Party, to discuss and evaluate the progress of activities under the Memorandum or to review other matters concerning the Memorandum, such as future policy and programmatic direction.
3. The Parties may enter into agreements under this Memorandum to undertake specific activities. Each agreement will specify: the scope of the activity; expected project period; responsibilities of the implementing agencies, including those related to funding and personnel assignments; anticipated results; reporting procedures, if appropriate; and any other relevant matters.
4. Each Party shall make available to the other parties all technical information obtained through the implementation of this Memorandum and such information will be made available to third parties, except that nothing in this Memorandum shall be construed to require a Party to make available or allow access to information:
   (a) the disclosure of which would impede law enforcement; or
   (b) that is protected from disclosure by U.S. law governing business or proprietary information, personal privacy, the confidentiality of internal government decision making processes, or protection of national security.
5. In the event that any activity undertaken by the parties to implement the purposes of this Memorandum involves access to and sharing or transfer of technology subject to patents or other intellectual property rights, such access and sharing or transfer will be provided on terms which recognize and are consistent with the adequate and effective protection of intellectual property rights.

V. Effective Date, Renewal, Amendment, Withdrawal and Termination

1. This Memorandum shall become effective upon signature by all parties and shall remain in effect for a period of five years. Unless one of the Parties notifies the other Parties in writing of its intent to terminate this Memorandum ninety days prior to its expiration, the Memorandum shall be automatically renewed for an additional five-year period. Thereafter, it may be renewed for successive five-year periods by written agreement of the Parties.

2. This Memorandum may be amended at any time by written agreement of the parties, including to add new parties. Any party may withdraw from this Memorandum after consultation with the other parties. The Memorandum may be terminated at any time after consultations among the parties. Unless otherwise agreed in writing, any Party's withdrawal from, or the termination of, this Memorandum shall not affect the validity or duration of activities undertaken pursuant to the Memorandum that have been initiated prior to, but not completed at the time of, such withdrawal or termination.

IN WITNESS WHEREOF, the undersigned have signed this Memorandum of Understanding.

Done this 3rd day of July, 1996.

FOR THE ENVIRONMENTAL PROTECTION AGENCY
Carol M. Browner
Administrator

FOR THE DEPARTMENT OF ENERGY
Hazel R. O'Leary
Secretary

FOR THE DEPARTMENT OF DEFENSE
William J. Perry
Secretary

Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques

Signed in Geneva May 18, 1977
Entered into force October 5, 1978
Ratification by U.S. President December 13, 1979
U.S. ratification deposited at New York January 17, 1980

The States Parties to this Convention,

Guided by the interest of consolidating peace, and wishing to contribute to the cause of halting the arms race, and of bringing about general and complete disarmament under strict and effective international control, and of saving mankind from the danger of using new means of warfare,

Determined to continue negotiations with a view to achieving effective progress towards further measures in the field of disarmament,

Recognizing that scientific and technical advances may open new possibilities with respect to modification of the environment,

Recalling the Declaration of the United Nations Conference on the Human Environment adopted at Stockholm on 16 June 1972,

Realizing that the use of environmental modification techniques for peaceful purposes could improve the interrelationship of man and nature and contribute to the preservation and improvement of the environment for the benefit of present and future generations,

Recognizing, however, that military or any other hostile use of such techniques could have effects extremely harmful to human welfare,

Desiring to prohibit effectively military or any other hostile use of environmental modification techniques in order to eliminate the dangers to mankind from such use, and affirming their willingness to work towards the achievement of this objective,

Desiring also to contribute to the strengthening of trust among nations and to the further improvement of the international situation in accordance with the purposes and principles of the Charter of the United Nations, Have agreed as follows:

Article I

1. Each State Party to this Convention undertakes not to engage in military or any other hostile use of environmental modification techniques having widespread, long-lasting or severe effects as the means of destruction, damage or injury to any other State Party.
2. Each State Party to this Convention undertakes not to assist, encourage or induce any State, group of States or international organization to engage in activities contrary to the provisions of paragraph 1 of this article.

Article II

As used in Article I, the term "environmental modification techniques" refers to any technique for changing — through the deliberate manipulation of natural processes — the dynamics, composition or structure of the Earth, including its biota, lithosphere, hydrosphere and atmosphere, or of outer space.

Article III

1. The provisions of this Convention shall not hinder the use of environmental modification techniques for peaceful purposes and shall be without prejudice to the generally recognized principles and applicable rules of international law concerning such use.
2. The States Parties to this Convention undertake to facilitate, and have the right to participate in, the fullest possible exchange of scientific and technological information on the use of environmental modification techniques for peaceful purposes. States Parties in a position to do so shall contribute, alone or together with other States or international organizations, to international economic and scientific cooperation in the preservation, improvement, and peaceful utilization of the environment, with due consideration for the needs of the developing areas of the world.

Article IV

Each State Party to this Convention undertakes to take any measures it considers necessary in accordance with its constitutional processes to prohibit and prevent any activity in violation of the provisions of the Convention anywhere under its jurisdiction or control.

Article V

1. The States Parties to this Convention undertake to consult one another and to cooperate in solving any problems which may arise in relation to the objectives of, or in the application of the provisions of, the Convention. Consultation and cooperation pursuant to this article may also be undertaken through appropriate international procedures within the framework of the United Nations and in accordance with its

Charter. These international procedures may include the services of appropriate international organizations, as well as of a Consultative Committee of Experts as provided for in paragraph 2 of this article.

2. For the purposes set forth in paragraph 1 of this article, the Depositary shall, within one month of the receipt of a request from any State Party to this Convention, convene a Consultative Committee of Experts. Any State Party may appoint an expert to the Committee whose functions and rules of procedure are set out in the annex, which constitutes an integral part of this Convention. The Committee shall transmit to the Depositary a summary of its findings of fact, incorporating all views and information presented to the Committee during its proceedings. The Depositary shall distribute the summary to all States Parties.
3. Any State Party to this Convention which has reason to believe that any other State Party is acting in breach of obligations deriving from the provisions of the Convention may lodge a complaint with the Security Council of the United Nations. Such a complaint should include all relevant information as well as all possible evidence supporting its validity.
4. Each State Party to this Convention undertakes to cooperate in carrying out any investigation which the Security Council may initiate, in accordance with the provisions of the Charter of the United Nations, on the basis of the complaint received by the Council. The Security Council shall inform the States Parties of the results of the investigation.
5. Each State Party to this Convention undertakes to provide or support assistance, in accordance with the provisions of the Charter of the United Nations, to any State Party which so requests, if the Security Council decides that such Party has been harmed or is likely to be harmed as a result of violation of the Convention.

Article VI

1. Any State Party to this Convention may propose amendments to the Convention. The text of any proposed amendment shall be submitted to the Depositary who shall promptly circulate it to all States Parties.
2. An amendment shall enter into force for all States Parties to this Convention which have accepted it, upon the deposit with the Depositary of instruments of acceptance by a majority of States Parties. Thereafter it shall enter into force for any remaining State Party on the date of deposit of its instrument of acceptance.

Article VII

This Convention shall be of unlimited duration.

Article VIII

1. Five years after the entry into force of this Convention, a conference of the States Parties to the Convention shall be convened by the Depositary at Geneva, Switzerland. The conference shall review the operation of the Convention with a view to ensuring that its purposes and provisions are being realized, and shall in particular examine the effectiveness of the provisions of paragraph 1 of Article I in eliminating

the dangers of military or any other hostile use of environmental modification techniques.

2. At intervals of not less than five years thereafter, a majority of the States Parties to the Convention may obtain, by submitting a proposal to this effect to the Depositary, the convening of a conference with the same objectives.
3. If no conference has been convened pursuant to paragraph 2 of this article within ten years following the conclusion of a previous conference, the Depositary shall solicit the views of all States Parties to the Convention, concerning the convening of such a conference. If one third or ten of the States Parties, whichever number is less, respond affirmatively, the Depositary shall take immediate steps to convene the conference.

Article IX

1. This Convention shall be open to all States for signature. Any State which does not sign the Convention before its entry into force in accordance with paragraph 3 of this article may accede to it at any time.
2. This Convention shall be subject to ratification by signatory States. Instruments of ratification or accession shall be deposited with the Secretary-General of the United Nations.
3. This Convention shall enter into force upon the deposit of instruments of ratification by twenty Governments in accordance with paragraph 2 of this article.
4. For those States whose instruments of ratification or accession are deposited after the entry into force of this Convention, it shall enter into force on the date of the deposit of their instruments of ratification or accession.
5. The Depositary shall promptly inform all signatory and acceding States of the date of each signature, the date of deposit of each instrument of ratification or accession and the date of the entry into force of this Convention and of any amendments thereto, as well as of the receipt of other notices.
6. This Convention shall be registered by the Depositary in accordance with Article 102 of the Charter of the United Nations.

Article X

This Convention, of which the English, Arabic, Chinese, French, Russian, and Spanish texts are equally authentic, shall be deposited with the Secretary-General of the United Nations, who shall send certified copies thereof to the Governments of the signatory and acceding States.

IN WITNESS WHEREOF, the undersigned, being duly authorized thereto by their respective governments, have signed this Convention, opened for signature at Geneva on the eighteenth day of May, one thousand nine hundred and seventy-seven.

DONE at Geneva on May 18, 1977.

ANNEX TO THE CONVENTION
CONSULTATIVE COMMITTEE OF EXPERTS

1. The Consultative Committee of Experts shall undertake to make appropriate findings of fact and provide expert views relevant to any problem raised pursuant to paragraph 1 of Article V of this Convention by the State Party requesting the convening of the Committee.
2. The work of the Consultative Committee of Experts shall be organized in such a way as to permit it to perform the functions set forth in paragraph 1 of this annex. The Committee shall decide procedural questions relative to the organization of its work, where possible by consensus, but otherwise by a majority of those present and voting. There shall be no voting on matters of substance.
3. The Depositary or his representative shall serve as the Chairman of the Committee.
4. Each expert may be assisted at meetings by one or more advisers.
5. Each expert shall have the right, through the Chairman, to request from States, and from international organizations, such information and assistance as the expert considers desirable for the accomplishment of the Committee's work.

UNDERSTANDINGS REGARDING THE CONVENTION

Understanding Relating to Article I

It is the understanding of the Committee that, for the purposes of this Convention, the terms, "widespread", "long-lasting" and "severe" shall be interpreted as follows:

(a) "widespread": encompassing an area on the scale of several hundred square kilometers;
(b) "long-lasting": lasting for a period of months, or approximately a season;
(c) "severe": involving serious or significant disruption or harm to human life, natural and economic resources or other assets.

It is further understood that the interpretation set forth above is intended exclusively for this Convention and is not intended to prejudice the interpretation of the same or similar terms if used in connection with any other international agreement.

Understanding Relating to Article II

It is the understanding of the Committee that the following examples are illustrative of phenomena that could be caused by the use of environmental modification techniques as defined in Article II of the Convention: earthquakes, tsunamis; an upset in the ecological balance of a region; changes in weather patterns (clouds, precipitation, cyclones of various types and tornadic storms); changes in climate patterns; changes in ocean currents; changes in the state of the ozone layer; and changes in the state of the ionosphere.

It is further understood that all the phenomena listed above, when produced by military or any other hostile use of environmental modification techniques, would result, or could reasonably be expected to result, in widespread, long-lasting or severe destruction, damage or injury. Thus, military or any other hostile use of environmental modification techniques as defined in Article II, so as to cause those phenomena as a means of destruction, damage or injury to another State Party, would be prohibited.

It is recognized, moreover, that the list of examples set out above is not exhaustive. Other phenomena which could result from the use of environmental modification techniques as defined in Article II could also be appropriately included. The absence of such phenomena from the list does not in any way imply that the undertaking contained in Article I would not be applicable to those phenomena, provided the criteria set out in that article were met.

Understanding Relating to Article III

It is the understanding of the Committee that this Convention does not deal with the question whether or not a given use of environmental modification techniques for peaceful purposes is in accordance with generally recognized principles and applicable rules of international law.

Understanding Relating to Article VIII

It is the understanding of the Committee that a proposal to amend the Convention may also be considered at any conference of Parties held pursuant to Article VIII. It is further understood that any proposed amendment that is intended for such consideration should, if possible, be submitted to the Depositary no less than 90 days before the commencement of the conference.

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1 These are not incorporated into the Convention but are part of the negotiating record and were included in the report transmitted by the CCD to the U.N. General Assembly in September 1976.

Excerpts from The 1987 Montreal Protocol on Substances that Deplete the Ozone Layer

United Nations Environment Programme
The Ozone Secretariat

as adjusted and amended by the second Meeting of the Parties
(London, 27-29 June 1990)

and by the fourth Meeting of the Parties
(Copenhagen, 23-25 November 1992)

and further adjusted by the seventh Meeting of the Parties
(Vienna, 5-7 December 1995)

Preamble

The Parties to this Protocol,

Being Parties to the Vienna Convention for the Protection of the Ozone Layer,

Mindful of their obligation under that Convention to take appropriate measures to protect human health and the environment against adverse effects resulting or likely to result from human activities which modify or are likely to modify the ozone layer,

Recognizing that world-wide emissions of certain substances can significantly deplete and otherwise modify the ozone layer in a manner that is likely to result in adverse effects on human health and the environment,

Conscious of the potential climatic effects of emissions of these substances,

Aware that measures taken to protect the ozone layer from depletion should be based on relevant scientific knowledge, taking into account technical and economic considerations,

Determined to protect the ozone layer by taking precautionary measures to control equitably total global emissions of substances that deplete it, with the ultimate objective of their elimination on the basis of developments in scientific knowledge, taking into account technical and economic considerations and bearing in mind the developmental needs of developing countries,

Acknowledging that special provision is required to meet the needs of developing countries, including the provision of additional financial resources and access to relevant technologies, bearing in mind that the magnitude of funds necessary is predictable, and the funds can be expected to make a substantial difference in the world's ability to address the scientifically established problem of ozone depletion and its harmful effects,

Noting the precautionary measures for controlling emissions of certain chlorofluorocarbons that have already been taken at national and regional levels,

Considering the importance of promoting international co-operation in the research, development and transfer of alternative technologies relating to the control and reduction of emissions of substances that deplete the ozone layer, bearing in mind in particular the needs of developing countries,

HAVE AGREED AS FOLLOWS:

Article 14: Relationship of this Protocol to the Convention

Article 15: Signature

Article 16: Entry into force

1. This Protocol shall enter into force on 1 January 1989, provided that at least eleven instruments of ratification, acceptance, approval of the Protocol or accession thereto have been deposited by States or regional economic integration organizations representing at least two-thirds of 1986 estimated global consumption of the controlled substances, and the provisions of paragraph 1 of Article 17 of the Convention have been fulfilled. In the event that these conditions have not been fulfilled by that date, the Protocol shall enter into force on the ninetieth day following the date on which the conditions have been fulfilled.
2. For the purposes of paragraph 1, any such instrument deposited by a regional economic integration organization shall not be counted as additional to those deposited by member States of such organization.
3. After the entry into force of this Protocol, any State or regional economic integration organization shall become a Party to it on the ninetieth day following the date of deposit of its instrument of ratification, acceptance, approval or accession.

Article 17: Parties joining after entry into force

Article 18: Reservations

No reservations may be made to this Protocol.

Article 19: Withdrawal

Any Party may withdraw from this Protocol by giving written notification to the Depositary at any time after four years of assuming the obligations specified in paragraph 1 of Article 2A. Any such withdrawal shall take effect upon expiry of one year after the date of its receipt by the Depositary, or on such later date as may be specified in the notification of the withdrawal.

Article 20: Authentic texts

Index

N

O

P

R

S

T

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